MIAMI GEOLOGICAL SOCIETY MEMOIR 3

SYMPOSIUM ON SOUTH FLORIDA GEOLOGY

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GEOGRAPHIC DISTRIBUTION

The Hawthorn Group underlies much of peninsular Florida (figures 4,5), although it is absent from most of the Ocala Arch and Sanford High due to erosion. Outliers of Hawthorn sediments occur scattered along the arch in lows and in some karst features. The Hawthorn Group sediments are also absent from part of Vernon's (1951) Kissimmee Faulted Flexure, presumably due to erosion.

The Hawthorn Group dips gently away from the Ocala Arch and Sanford High at generally less than 6 feet per mile (figure 4). In north Florida the Hawthorn dips generally to the east and northeast towards the Jacksonville Basin and the east coast. Locally the dip may become greater and may reverse in some areas. This is due to post depositional movement related to karst activity, possible faulting, and tilting of the platform. Scott (1983) indicated this on structure maps of the Ocala (p.26) and Hawthorn (p. 32).

In central and south Florida the Hawthorn Group dips gently to the south and southeast with local variations (figure 4). Generally, farther south in the state the dip is more southeasterly.

The Hawthorn Group ranges in thickness from a feather edge along the positive features to greater than 500 feet in the Jacksonville Basin and greater than 700 feet in the South Florida Basin (figure 5). The Hawthorn generally thickens to the northeast in North Florida toward the Jacksonville Basin and southward into the South Florida Basin (figure 5).

NORTH FLORIDA

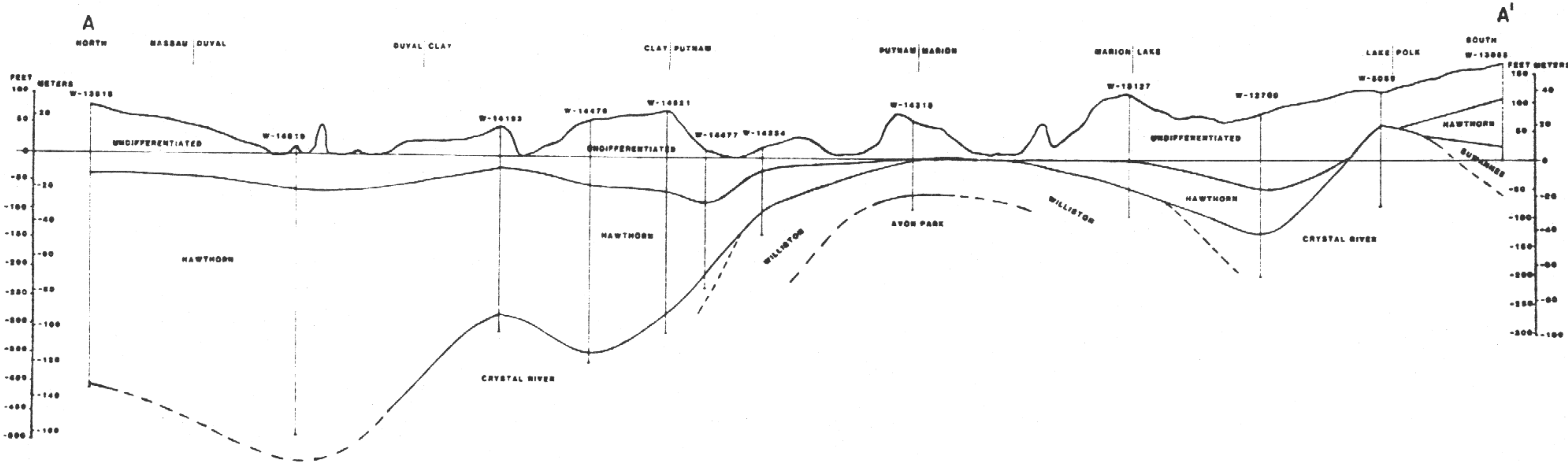
The most diverse sequence of Hawthorn Group lithologies occurs in North Florida. Clastic sediments dominate the Hawthorn in this area and generally decrease southward (Scott, 1983). Northward into Georgia, carbonates (limestone and dolomite) typically become less common. The facies changes within these sediments are both rapid and frequent. As a result, the north Florida Hawthorn has proven problematical for stratigraphers.

The clastic sediments within the Hawthorn Group are predominately quartz sand and clay minerals. Palygorskite and montmorillonite are the predominant clay minerals present with varying amounts of illite and more rarely kaolinite and chlorite. Feldspar, mica, and heavy minerals also occur in relatively minor amounts.

The carbonate sediments present are predominantly dolomites, with minor occurence of dolomitic limestones. The carbonate sediments vary from very hard and recrystallized dolomites to soft dolomites, to soft dolosilts (silt-sized dolomite) all with varying admixtures of clastic material.

The Hawthorn Group in this area can be separated into three formations that are correlative with the units of the Hawthorn Group in Georgia as designated by Huddlestun (1984). These units are informally referred to here as units A,B, and C. Formal names have not been applied to the units in Florida, but new nomenclature will be proposed in the near future (Scott, manuscript in preparation). The generalities of the Hawthorn Group in North Florida and Georgia are shown in Table 1. Lithologically, the units compare well. However, the chronostratigraphic positioning of the formations in Florida is based on extremely limited data due to the loss of fossils from extensive dolomitization and the paucity of paleontologic studies.

Unit C, the basal unit of the Hawthorn Group in northeastern Florida, is composed primarily of dolomite with interbedded quartz sands and clays. Unit C lies directly on the Eocene


A
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SOUTH
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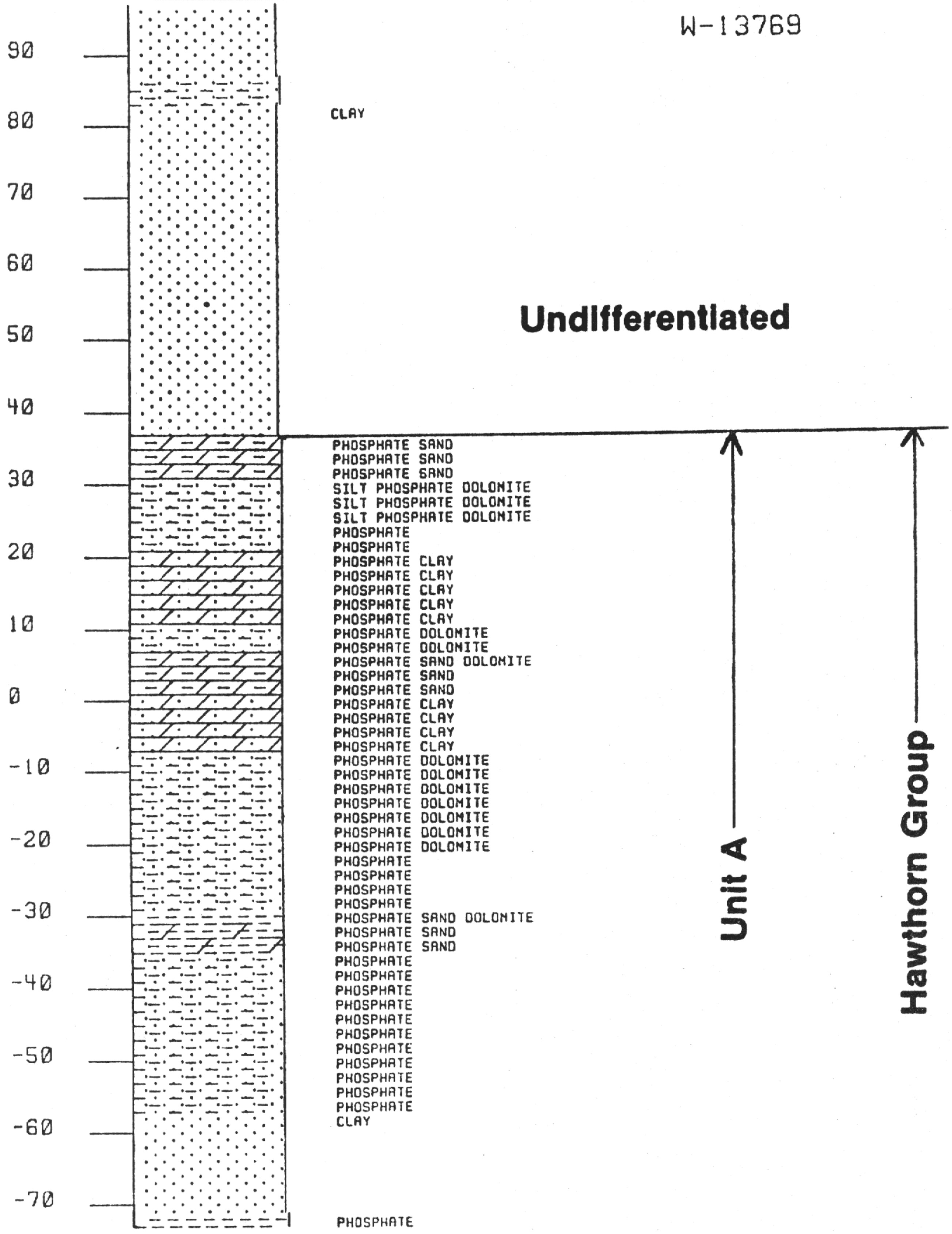
DUVAL CLAY
CLAY PUTNAM
PUTNAM MARION
MARION LAKE
LAKE POLK
FEET
METERS
UNDIFFERENTIATED
HAWTHORN
CRYSTAL RIVER
WILLISTON
AVON PARK
SUWANNEE

Figure No. 6

TABLE 1

		S.E. Ga. Coastal Plain	Northeastern Florida	Eastern Central Florida	Western Central Florida	South Florida
Pliocene	Lower	Cypresshead Fm.	Cypress-head Fm. ?	Tamiami Fm. Wabasso Beds	Tamiami Fm. Upper Bone Valley Fm.	Tamiami Formation
Miocene	Upper (Late)			Unit D (Hawthorn Group)	Lower Bone Valley (Hawthorn Group)	
Miocene	Middle	Coosawhatchie Fm. (Hawthorn Group)	Unit A (Hawthorn Group)	? Unit E ? (Hawthorn Group)	Upper Hawthorn ? (Hawthorn Group)	Upper Hawthorn (Hawthorn Group)
Miocene	Lower (Early)	Marks Head Fm. Parachucla Fm. (Hawthorn Group)	Unit B Unit C (Hawthorn Group)	Unit E ? ? ? ? Unit C (Hawthorn Group)	Lower Hawthorn ? Upper "Tampa" Lower "Tampa" "Tampa" Tampa Fm. (Hawthorn Group)	Lower Hawthorn Tampa Formation (Hawthorn Group)
Oligocene				? ?	Suwannee Limestone	Suwannee Limestone
Eocene		Ocala Group	Ocala Group	Ocala Group	Ocala Group	Ocala Group Avon Park Limestone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CLAY
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Unit A
Hawthorn Group

Figure No. 7

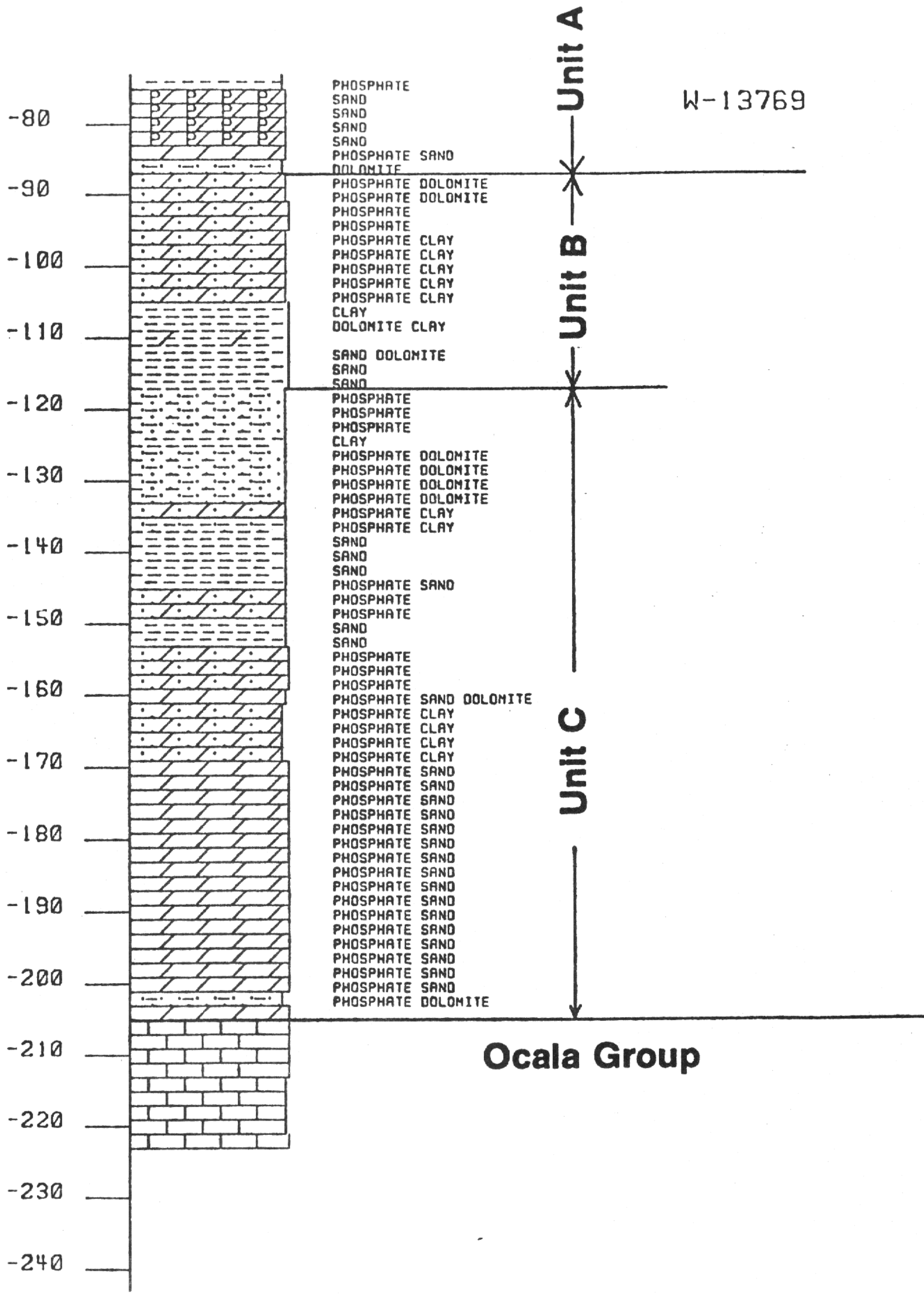


Figure No. 7 (Continued)

Ocala Group limestones or rarely on the Oligocene Suwannee Limestone. The dolomites are medium gray (N5) to brownish (10YR6/2) sandy and phosphatic (to 15%) with clay in some zones. They are generally moderately to well indurated and appear to be replacement dolomites. Commonly, the dolomites of Unit C contain abundant intraclasts of dolomite that were redeposited in a similar dolomitic matrix. The intraclasts generally have a rim of replacement phosphorite which allows them to be easily differentiated from the dolomitic matrix.

The sands and clays in Unit C become more abundant toward the top of the unit. The quartz sands are fine to coarse, moderately to poorly sorted, variably phosphatic, dolomitic, and clayey. The sands range from olive gray (5Y3/2) to light medium gray (N6) in color. The clays are olive green to olive gray, variably sandy, silty, phosphatic and dolomitic. The clay beds are most common in the upper part of the unit.

Unit C ranges in thickness from zero on the Ocala Uplift and Sanford High to greater than 150 feet in the Jacksonville Basin. The top of the unit ranges from 80 feet above sea level to greater than 330 feet below sea level. Unit C is graphically represented in figure 7.

The fauna from Unit C is very sparse, although mollusk molds are common in the dolomites. Virtually everything has been diagenetically obliterated. However, in one well in Nassau County a calcareous quartz sand section containing foraminifera was encountered near the base of Unit C. The foraminifera from this section, which were identified by P. Huddlestun of the Georgia Geological Survey, indicate an Early Miocene, Lower Aquitanian Age (Huddlestun, 1983, personal communication). This has been the only datable assemblage thus far encountered in Unit C.

Unit B immediately overlies Unit C with an apparent disconformity (figure 7). The unconformity is generally not easily recognized in north Florida, but is suggested by lithologic changes and by correlations with units B and C in Georgia, where the unconformity is biostratigraphically and lithostratigraphically recognized. In north Florida, a rubble zone is occasionally noted at the base of Unit B. Also, a hard dolomite layer in often present at the top of Unit C that is bored and has an upper surface of phosphatized dolomite.

Unit B is quite lithologically variable, containing dolomites, clays, and quartz sands. The dolomites range from soft to hard with highly variable quartz sand and clay content. Phosphate content is also quite variable but generally less than ten percent. Color ranges from yellowish gray (5Y7/2) to olive gray (5Y3/2). Dolomite layers occur scattered throughout the unit with a dolomite bed often present at the top of the unit.

The clay beds within Unit B are greenish gray (5GY6/1) to olive gray (5Y4/1), variably silty, sandy, dolomitic, and phosphatic (generally less than five percent). The clays have a decided fuller's earth character in that, when dry, the clay clings tenaciously to one's tongue. X-ray diffraction analysis of these clays indicate that palygorskite is commonly the dominant clay mineral.

The sand beds present in Unit B are typically light gray (N7) to olive gray (5Y4/1) in color, dolomitic, phosphatic and clayey. Phosphate content is highly variable although generally less than 15-20 percent.

Unit B ranges in thickness from 0 to 130 feet. The upper surface of Unit B ranges in elevation from 110 feet above sea level to 160 feet below sea level.

Unit B is typically unfossiliferous, containing only scattered mullusk molds. Lithologic correlation to Hawthorn sediments in Georgia suggest an Early Miocene, Lower Burdigalian Age (based on evidence collected by Huddlestun, personal communication, 1983).

Unit A unconformably overlies Unit B (figure 7). The base of Unit A often contains a phosphatic rubble zone consisting of phosphatized dolomite clasts in a sandy matrix. Dolomite layers in the basal portions of Unit A appear similar to the dolomites of Unit B, although they are interbedded with sands and clays of Unit A. The contact is below the lowest occurrence of the clastic beds of Unit A.

In general Unit A contains more carbonate in the upper part than in the lower, although dolomite beds do occur lower in the section. Conversely, clay and sand beds are more common in the basal portion of the unit. The dolomites are generally light gray (N7) to greenish gray (5GY6/1) and light olive gray (5Y6/1) in color, poorly to moderately indurated, sandy, phosphatic and often clayey. The phosphate content is variable but generally less than 10 percent. The dolomites in the upper part of Unit A tend to become more calcareous toward the northeast into the Jacksonville Basin. Also incorporated in Unit A are dolomitic to calcareous, recrystallized, shelly limestones.

The quartz sands of Unit A are greenish gray (5GY6/1) to olive gray (5Y4/1) in color, fine to medium grained, poorly to moderately sorted, clayey, dolomitic, and phosphatic. Phosphate is generally in variable quantities but usually less than 10 percent.

The clays are light olive gray (5Y6/1) to olive gray (5Y4/1), sandy, silty, dolomitic, and phosphatic. Mica is often present in very minor amounts. Clay beds are most common in the lower portion of the unit, increasing in proportion eastward (Scott, 1983).

Unit A is thickest in the Jacksonville Basin where it attains a thickness of 200 feet. It is absent over the Ocala Uplift and the Sanford High. The top of the unit ranges from 170 feet above sea level to 100 feet below sea level in northern Florida.

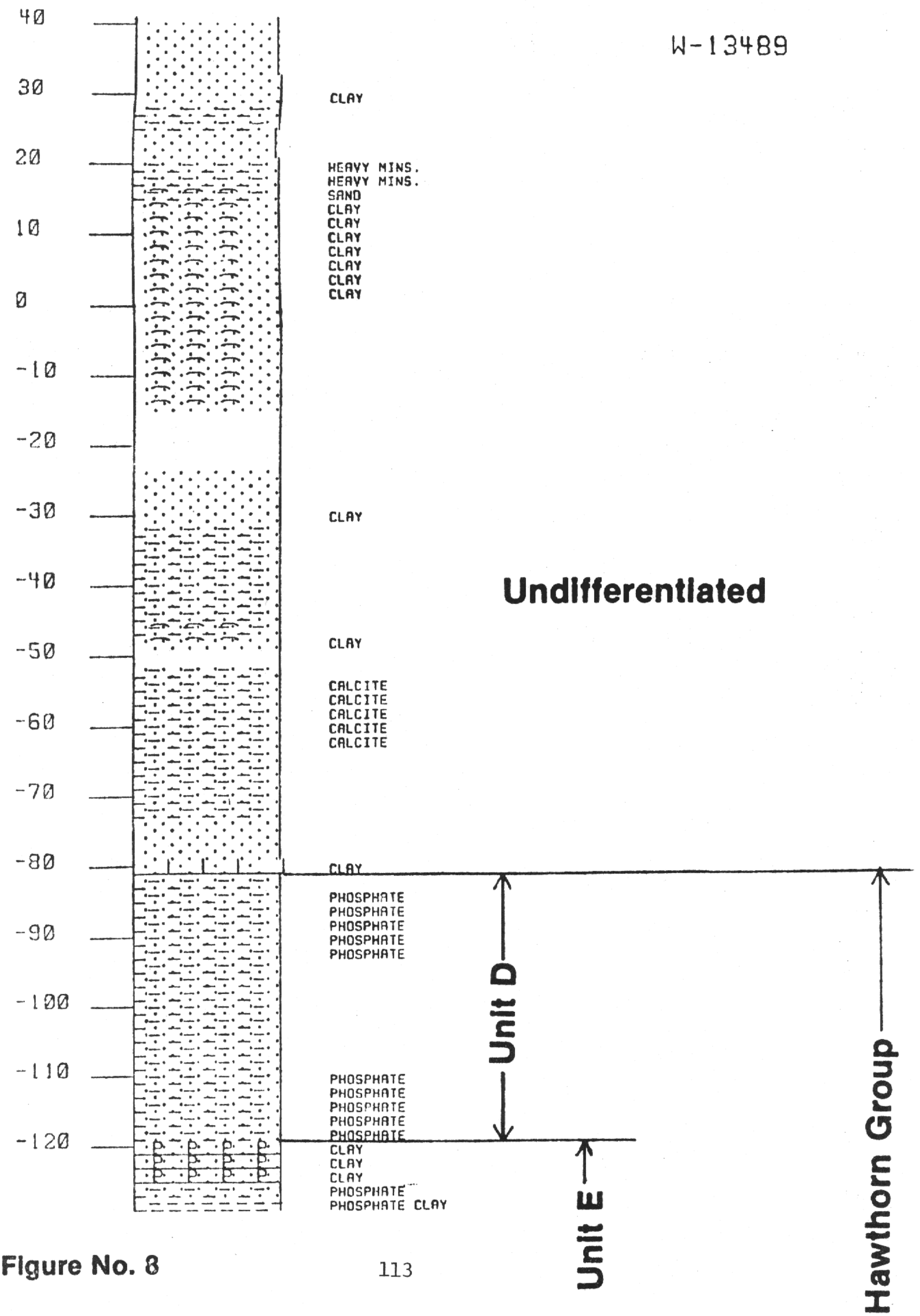
Faunally, Unit A has yielded a datable suite of diatoms. Hoenstine (1983) found diatoms in the clays of the lower part of the unit that indicated a Middle Miocene age for the unit. Huddlestun (1984) suggests a Servillian age for the unit.

The upper portion of Unit A grades northwestward into the "Statenville Member of the Coosawhatchie Formation" of Huddlestun (1984). The Statenville is a thin bedded, crossbedded, sequence of interbedded dolomitc layers and sand beds all containing various proportions of phosphate. The Statenville is actively mined for its phosphate content in Hamilton County.

CENTRAL FLORIDA - EASTERN PENINSULAR AREA

The transition from the sediments of the Hawthorn Group in north Florida to the Hawthorn sediments in the central Florida region is recognizable in the area between the Ocala Uplift and the Sanford High which Riggs (1979) referred to as the Kissimmmee Saddle. The Hawthorn Group thins both depositionally and due to erosion in the transition zone (figure 5). The top of the Hawthorn Group ranges from 0 to 150 feet below sea level in the Central Florida area (figure 4). It ranges in thickness from absent to greater than 150 feet thick (figure 5).

Correlations between the sediments of the northern area and the transition zone become more difficult to the south and southeast. The basal unit of the group, Unit C, appears to continue through the transition zone and is equivalent to the basal unit of the Hawthorn Group in eastern Orange, Brevard, and Osceola counties. The correlation of Units A and B to formations in Central Florida is very tenuous due to the paucity of cores in the area. As a result, the Hawthorn Group in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PHOSPHATE
PHOSPHATE
PHOSPHATE
CLAY
CLAY
CLAY
PHOSPHATE
PHOSPHATE CLAY
Undifferentiated
Unit D
Unit E
Hawthorn Group

Figure No. 8

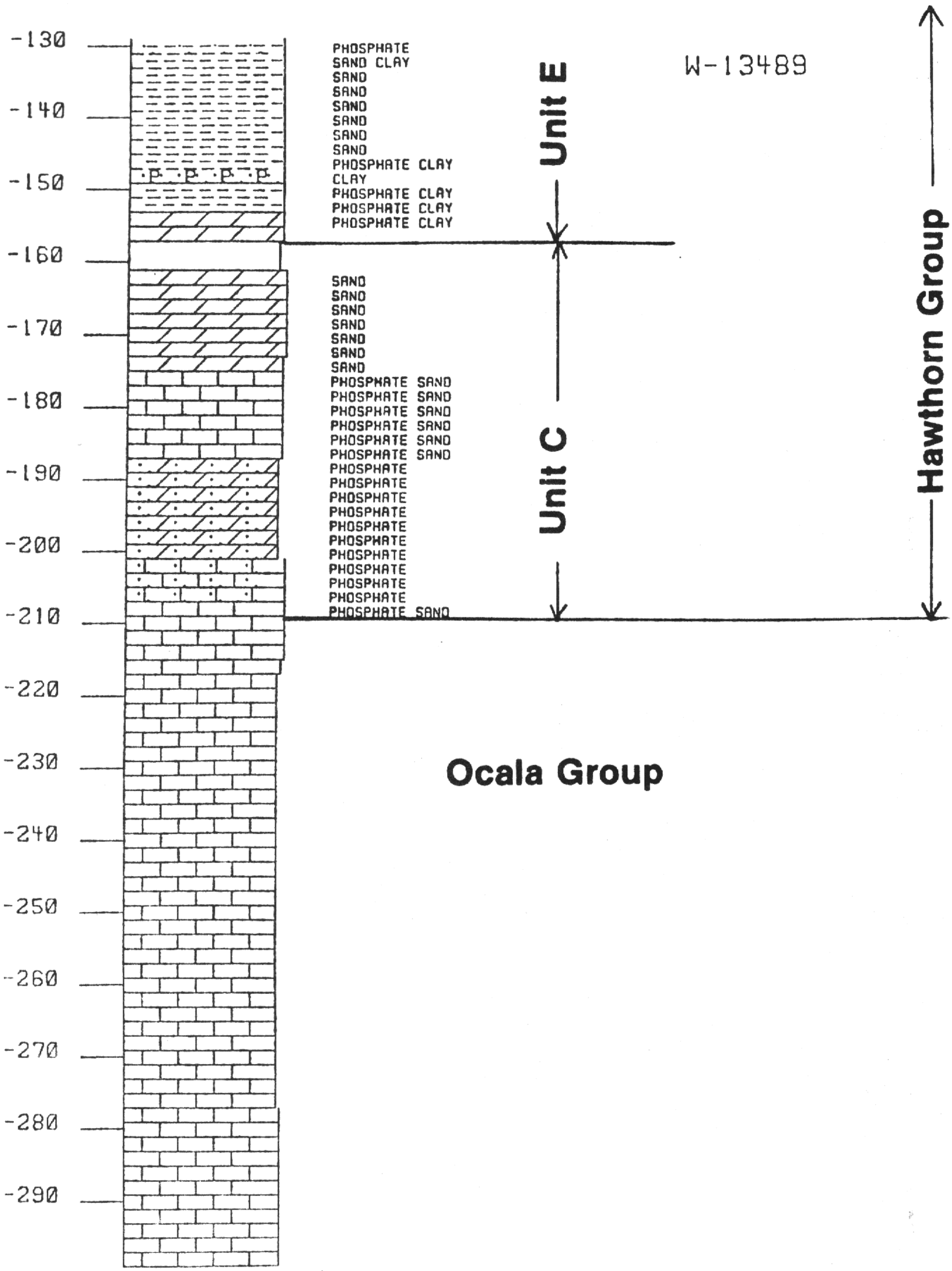


Figure No. 8 (Continued)

the eastern central Florida region is subdivided into Units D,E, and C in descending order (figure 8). Suggested correlations are shown in Table 1. Cross section B-B (figure 9) shows the general relationships of the Hawthorn Group to overlying and underlying formations.

Unit C in this area lacks the upper sandy member that is present in northern Florida. The unit consists predominantly of a moderately to well indurated sandy, phosphatic, sometimes clayey dolomite and limestone. The carbonates range in color from white (N9) and yellowish gray (5Y8/1) to olive gray (5Y4/1). Molds of mollusk shells are very common with some zones being very recrystallized dolomite to calcareous shell beds. Unit C contains more sand and clay beds south and southeast of the Brevard Platform. At least part of Unit C grades downdip to the east of the Brevard Platform into a non-phosphatic, slightly sandy limestone. Previous investigations in this area have referred this limestone to the Suwannee Limestone of Oligocene Age (Bermes, 1958; Brown et al 1662). However, planktonic foraminifera indicate an Early Miocene Age (Huddlestun, personal communication, 1983).

Unit C varies in thickness from being absent on the Brevard Platform to as much as 70 feet thick in the Osceola Low. The limestones of the Ocala Group immediately underlie this unit, except in the coastal areas of southern Brevard and Indian River counties where Lower Miocene limestone underlies the Hawthorn Group.

The fauna of Unit C consists predominantly of mollusk molds. Diagenesis has altered these sediments to such an extent that the fossils have for the most part been obliterated. The age of this unit is inferred from its correlation with Unit C in northern Florida where it is thought to be of Early Miocene age.

Unit E lies directly on the carbonates of Unit C (figure 8). The transition from C to E is often abrupt with a weathered looking dolomite below the contact suggesting an unconformity. Farther to the south the transition appears more gradational. unit E is predominantly a clastic unit with carbonate occurring as matrix and as occasional dolomite lenses. The sands in this unit are very fine to medium grained (occasionally coarser), poorly to moderately sorted, poorly to moderately indurated, phosphatic, clayey, dolomitic quartz sands. The color ranges from medium gray (N5-N6) to grayish green (10GY)5/2) and greenish gray (5GY6/1).

Clay occurs both as a matrix material and as individual beds. Generally the clays contain varying amounts of silt, quartz, sand, phosphate, and carbonate, usually dolomite. They range in color from light olive gray (5Y6/1) to olive gray (5Y4/1) and yellowish gray (5Y8/1). The dominant clay minerals appear to be montmorillonite and palygorskite.

Phosphorite sand beds occur within Unit E, and some of the beds are rich enough to be of interst as a source of phosphate. Commonly, there are several zones of phosphorite within this unit. This is particularly true just off the Brevard Platform to the southwest and south in Brevard and Osceola counties. The upper-most zone occurs just below the contact with the overlying Unit D. Other lithic zones occur scattered throughout Unit E.

A number of carbonate beds occur within Unit E. These are generally thin dolomites of limited extent, which range from dolosilts to recrystallized limestones with abundant molds of mollusks. All contain varying amounts of silt, quartz sand, phosphate and clay.

Unit E is more clayey in the area west of the Brevard Platform, southwest of the Sanford High, in and on the east flank of the Osceola Low in Orange and Osceola counties. To the south of this area the unit becomes more sandy with more frequent carbonate beds.

Unit E is thinnest on the Brevard Platform and thickens off the platform to the east, south and west. It attains a maximum thickness of 80 feet in cores in southern Brevard and Indian River counties.

Fossils in Unit E are very scarce. Mollusk molds are the most common fossils encountered, and molds of diatom frustrules are found in some of the clay beds, most fossil remains appear to have been destroyed by extensive diagenesis. Rough correlations of the lower part of E with Unit B of north Florida and the upper part of E with Unit A may prove valid when more data become available.

Unit D lies unconformably on Unit E in the Southeastern part of the state where the unconformity is often marked by a very prominent rubble zone consisting of dolomite, phosphatized dolomite and microsphorite clasts in a clayey sand matrix (figure 8). This unit has been informally referred to as the "Lean Green" referring to its green color and low phosphate content.

The "Lean Green" (Unit D) is characteristically a fine to coarse grained, poorly sorted quartz sand. It varies from calcareous to dolomitic, fossiliferous to nonfossiliferous, clayey, and slightly phosphatic. Unit D It is typically light olive gray (5Y6/1) to olive gray (5Y4/1). The sediments of D become more dolomitic, less fossiliferous with depth toward the contact with Unit E.

Unit D thins onto the Brevard Platform where it is mostly absent. It thickens off the platform to the west into the Osceola Low and to the south and southeast. It reaches a maximum thickness of nearly 70 feet in Indian River County where it includes the sediments referred to as the "Indian River beds" (now referred to as the Wabasso beds) of Early Pliocene age by Huddlestun, et al (1982).

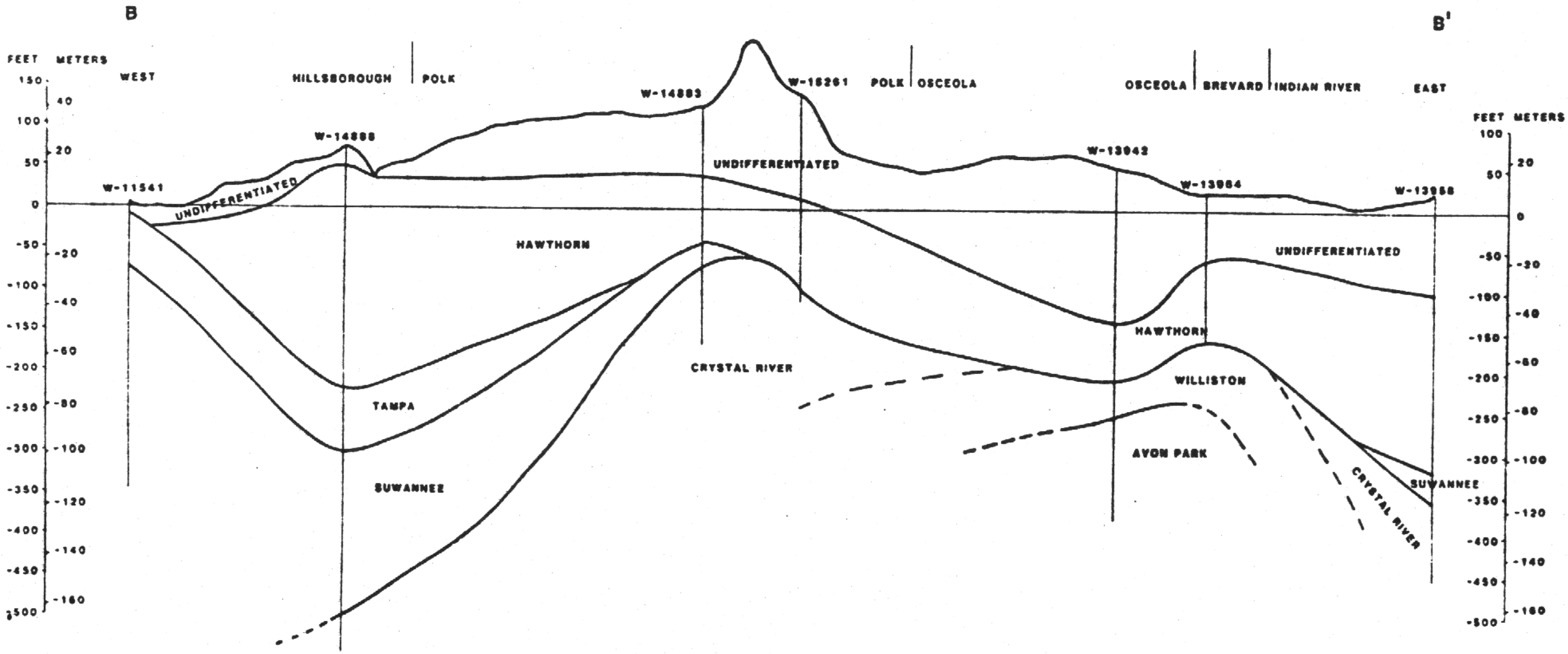
Fossil remains of Unit D include mollusks (usually thin shelled pectens), planktic and benthic foraminifera, and diatoms. With the exception of the "Indian River beds" (Wabasso beds) of Early Pliocene, no age has been formally assigned to the "Lean Green." It appears that this unit thickens to the south and may correlate with the Upper Hawthorn sediments as found in F.P.L.well # 1 in Martin County. At this site planktic foraminifera indicated a Late Miocene age for the sediments (Huddlestun, personal communication, 1983). Obviously more data is needed to substantiate the correlation and age.

The Hawthorn Group in eastern Central Florida is overlain by Plio-Pleistocene undifferentiated sands, shell beds and limestones. These sediments are generally calcareous, with very little or no clay content, slightly phosphatic and poorly to moderately indurated. Color of the undifferentiated sediments are generally white (N9) to light gray (N7) or yellowish gray (5Y8/1). The contact between the overlying sediments and the Hawthorn Group is generally fairly abrupt although reworking can obscure this contact to some degree.

CENTRAL FLORIDA - WESTERN PENINSULAR AREA

The Hawthorn Group of the western peninsular area of central Florida differs considerably from its eastern correlative. The Hawthorn Group of the western area contains a significantly greater carbonate content as compared to the more clastic nature of the group in the east. In the western area the upper "Hawthorn" contains a greater proportion of clastics than does the lower "Hawthorn." This is similar to the differences between Units C and E in the east.

The Hawthorn Group of the western area informally consists of the following: in ascending order, the lower "Tampa" or "Tampa sand and clay unit" (Wilson, 1977), the upper "Tampa", lower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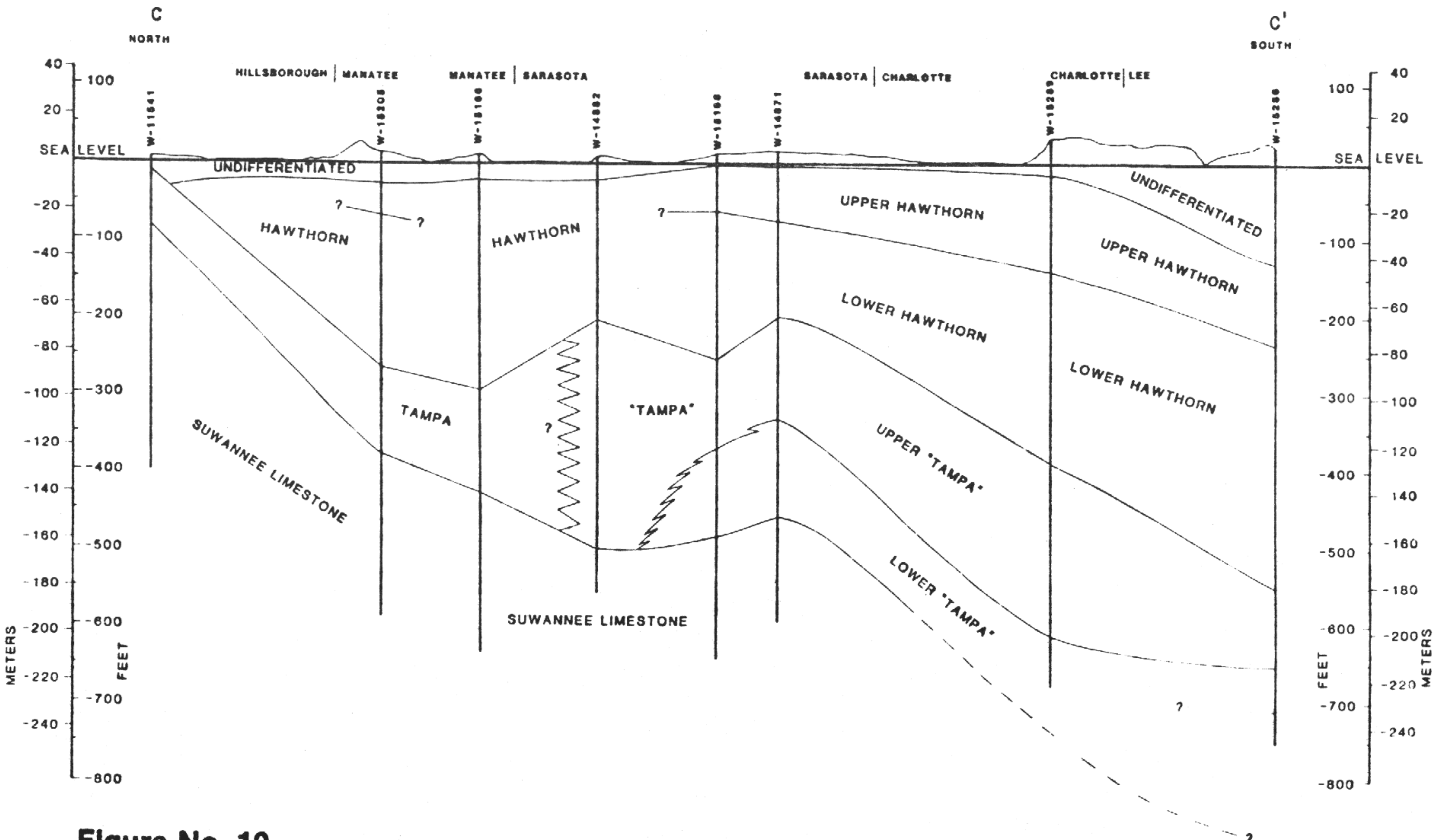
W-14883
W-15261
W-13942
W-13984
W-13958
UNDIFFERENTIATED
UNDIFFERENTIATED
UNDIFFERENTIATED
HAWTHORN
HAWTHORN
TAMPA
SUWANNEE
SUWANNEE
CRYSTAL RIVER
CRYSTAL RIVER
WILLISTON
AVON PARK

Figure No. 9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SUWANNEE LIMESTONE
SUWANNEE LIMESTONE
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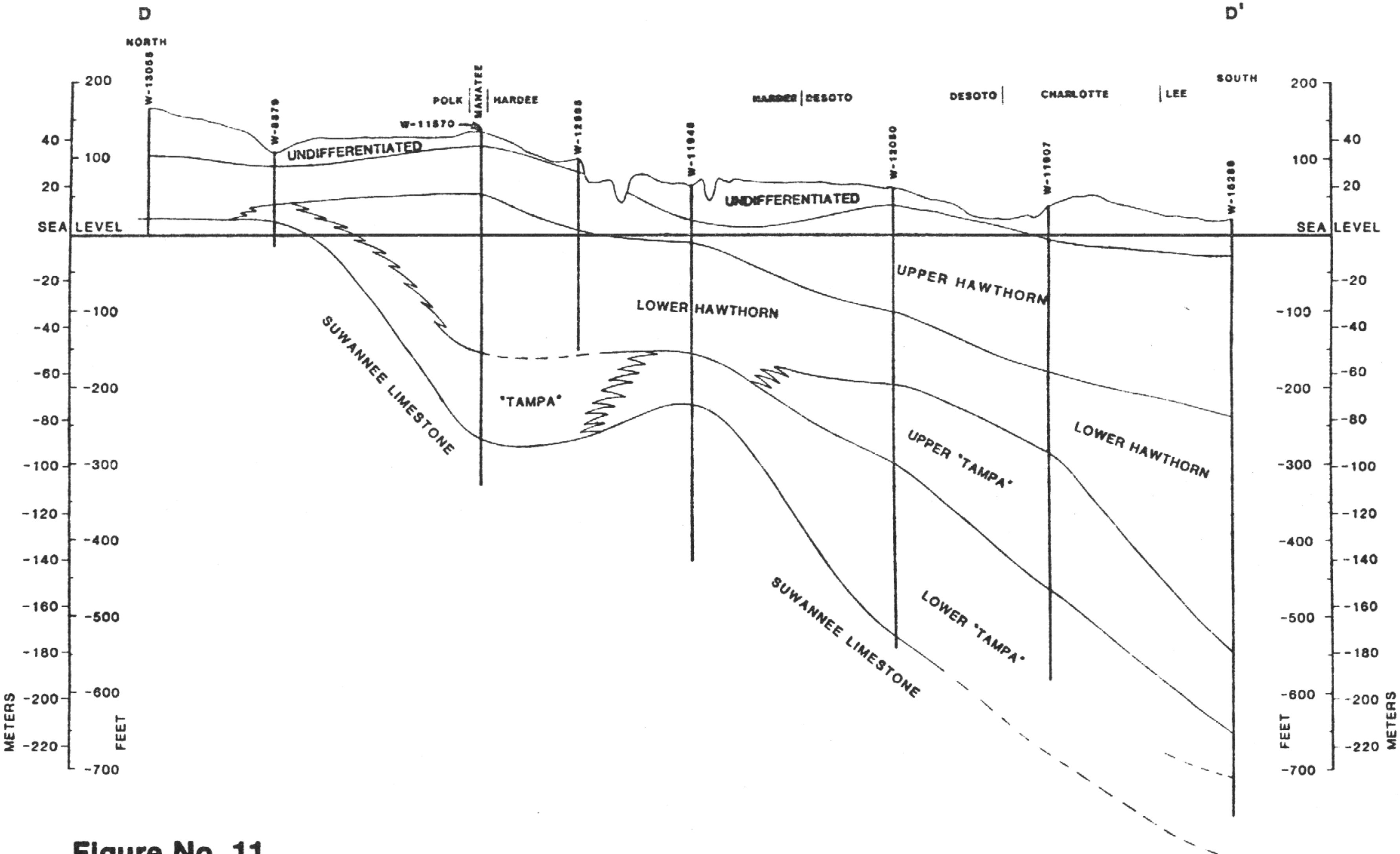
Figure No. 10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"TAMPA"
UPPER "TAMPA"
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METERS
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Figure No. 11

"Hawthorn," upper "Hawthorn" and the Bone Valley formations. The use of the term "Hawthorn Group is not formally acceptable and proper terminology will be proposed with the formal designation of the Hawthorn as a group. Figures 10 and 11 (cross sections C-C and D-D) show the regional relationships of the Hawthorn Group.

The lower "Tampa" or "Tampa sand and clay unit" of the Hawthorn Group consists of calcareous to very calcareous quartz sands and clays to very quartz sandy limestones (occasionally dolomite), with phosphate (up to 20 percent). The color range from white (N9) to yellowish gray (5Y8/1) in the sandy, sometimes clayey, phosphatic limestones. Texturally,these limestones are generally wackestone to rarely packstone, and they are occasionally dolomitic. Occasional dolomites are sandy phosphatic, grayish brown (5YR3/2) to dark yellowish brown (10R4/2), in color, microcrystalline to finely crystalline. Very recrystallized shell beds occur within this unit.

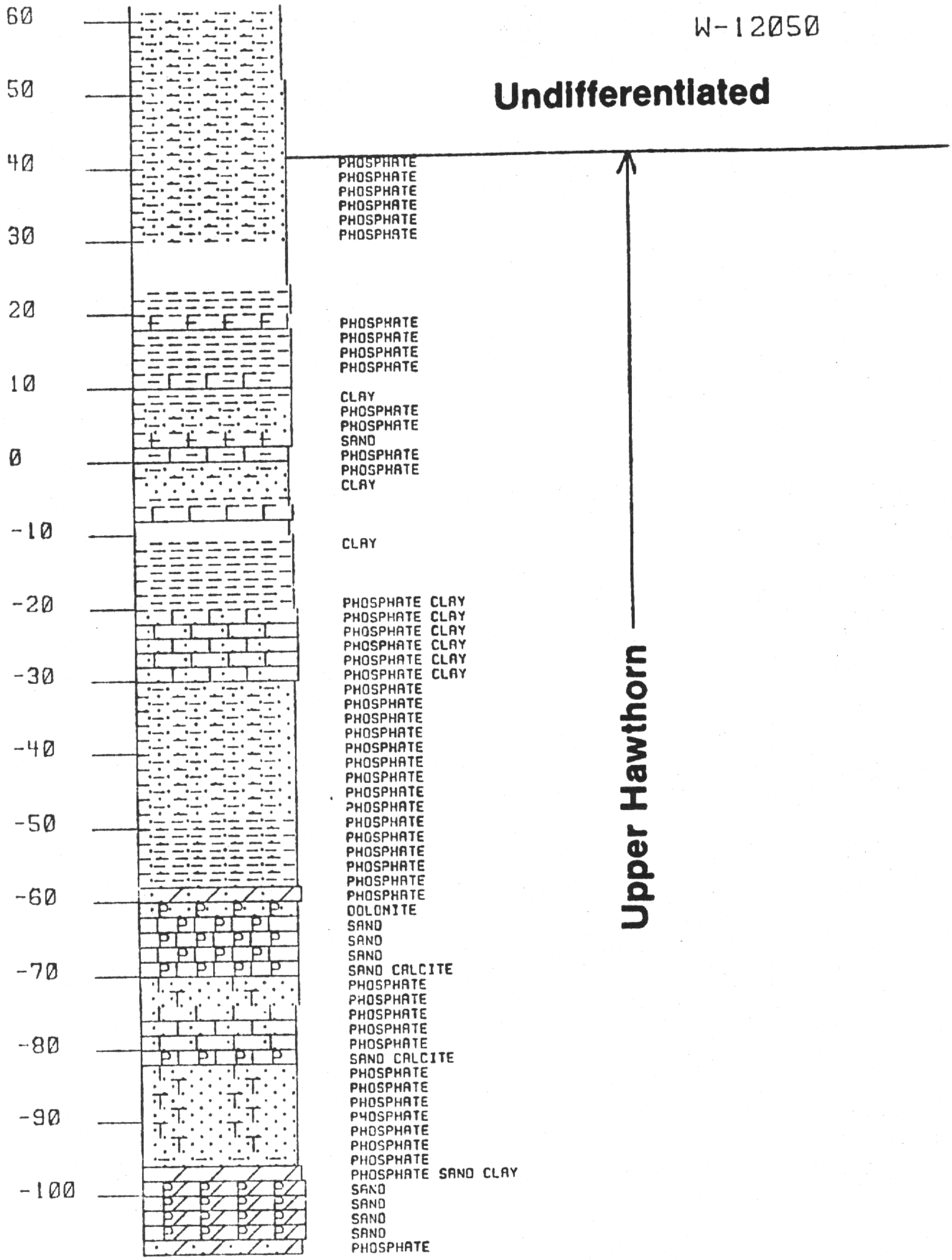
The quartz sands of the lower "Tampa" are generally fine to very fine grained, moderately sorted, moderately indurated, white (N9) to yellowish gray (5Y8/1), calcareous, and sometimes clayey. The clays are yellowish gray (5Y8/1) to olive gray (5Y4/1), quartz sandy, silty, phosphatic, and calcareous to dolomitic.

The lower "Tampa" is best developed in parts of Desoto, Hardee, Manatee and Sarasota counties and extends into Charlotte, Lee, and Polk counties. Outside the areas where it is best developed, this unit becomes predominantly a carbonate facies with scattered clastic lenses, thus becoming more difficult to distinguish from the overlying unit. The configuration of this unit can be seen in cross section C-C' and D-D' (figures 10,11). The lower "Tampa" ranges from 0 to more than 200 feet thick Figure 12 shows a stratigraphic and lithologic column of core W-12050 in the area where the lower "Tampa" reaches maximum development. The lower "Tampa" is underlain immediately by limestones referred to as the Suwannee Limestone of Oligocene Age.

Little is known concerning the age of the lower "Tampa" due to the lack of paleontologic investigations and available fossils, which occur within this unit mainly as molds. It is possible that the lower "Tampa" grades eastward into the lower dolomites of the Hawthorn Group. This suggested correlation implies an Early Miocene age based on previously discussed correlations with north Florida and Georgia. However, King and Wright (1979) suggested a Late Oligocene age for the Tampa in its type area. Such an age implies an older age for the basal Unit C, if it is correlative with this unit, or, that this unit is not present in the Hawthorn Group in eastern central Florida. As is shown in the cross section (figures 10,11), the lower "Tampa" facies changes into "Tampa" (undifferentiated "Tampa") which grades into type Tampa Formation of King and Wright (1979).

The upper "Tampa" overlies the lower "Tampa" gradationally, and the break between them is placed where the limestones become more phosphatic and more clastic in nature, changing to calcareous quartz sands, clays and very sandy limestones. The "Tampa" and the upper "Tampa" are very lithologically similar to the type Tampa Formation but are not within the areal limits of the formation as defined by King and Wright (1979). Also, because they have a slightly greater phosphate content (1 to 3 percent),they are therefore referred to here with the appropriate quotes.

The upper "Tampa" and the "Tampa" as used here are predominantly quartz sandy wackestones to calcareous mudstones containing less than 3 percent phosphate, and varying amounts of clay usually disseminated in the carbonate matrix. Less commonly the carbonates become granular enough to be termed a quartz sandy packstone. Occasionally the quartz sand component dominates, becoming a calcareous quartz sandstone. Dolomite does occur but is relatively uncommon. The "Tampa" and the upper "Tampa" range in color from white (N9) to yellowish gray (5Y8/1).


W-12050
Undifferentiated
Upper Hawthorn
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PHOSPHATE
CLAY
PHOSPHATE
PHOSPHATE
SAND
PHOSPHATE
PHOSPHATE
CLAY
CLAY
PHOSPHATE CLAY
PHOSPHATE CLAY
PHOSPHATE CLAY
PHOSPHATE CLAY
PHOSPHATE CLAY
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PHOSPHATE
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PHOSPHATE
PHOSPHATE
PHOSPHATE
PHOSPHATE
PHOSPHATE
PHOSPHATE
DOLOMITE
SAND
SAND
SAND
SAND CALCITE
PHOSPHATE
PHOSPHATE
PHOSPHATE
PHOSPHATE
PHOSPHATE
SAND CALCITE
PHOSPHATE
PHOSPHATE
PHOSPHATE
PHOSPHATE
PHOSPHATE
PHOSPHATE
PHOSPHATE
PHOSPHATE SAND CLAY
SAND
SAND
SAND
SAND
PHOSPHATE

Figure No. 12

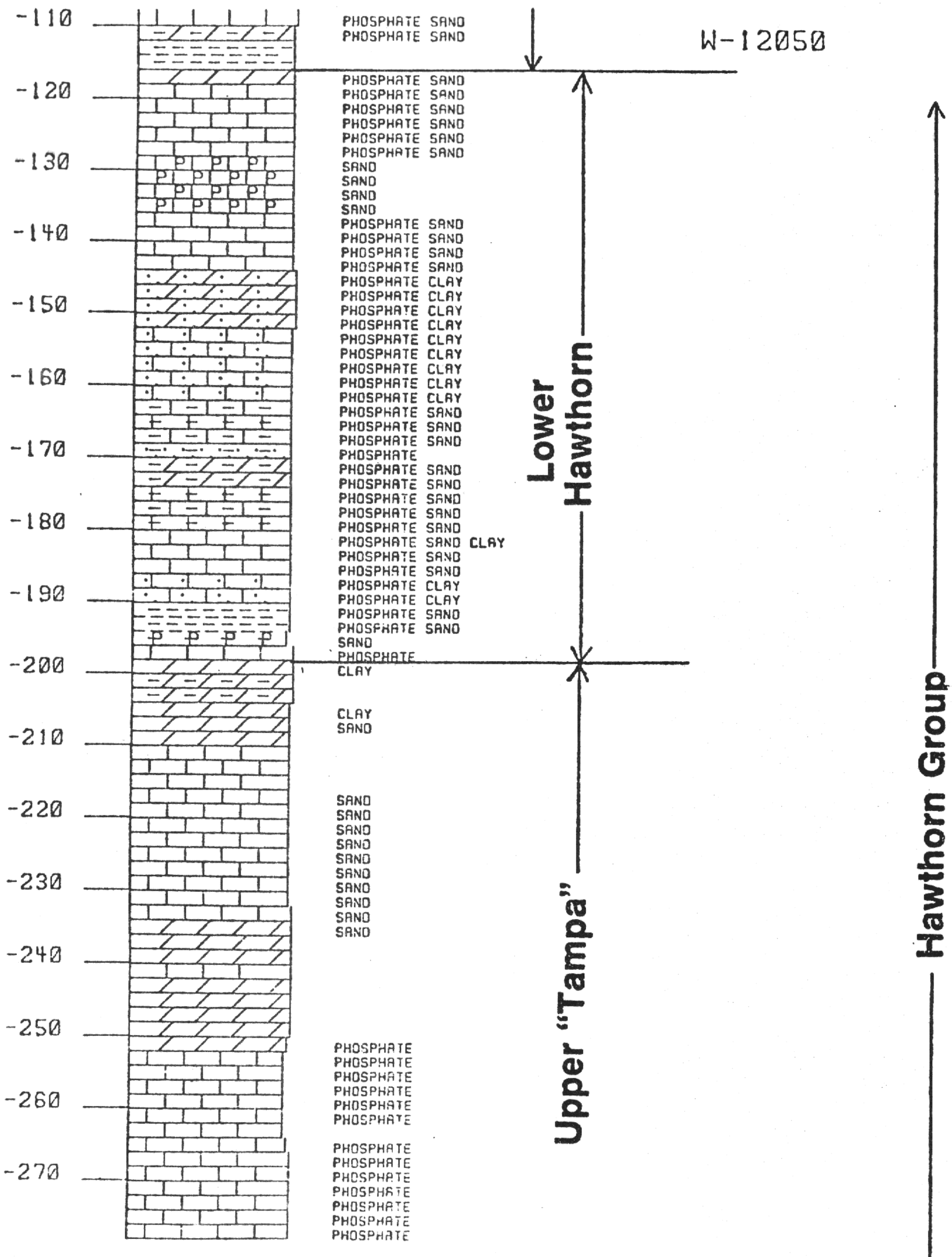


Figure No. 12 (Continued)

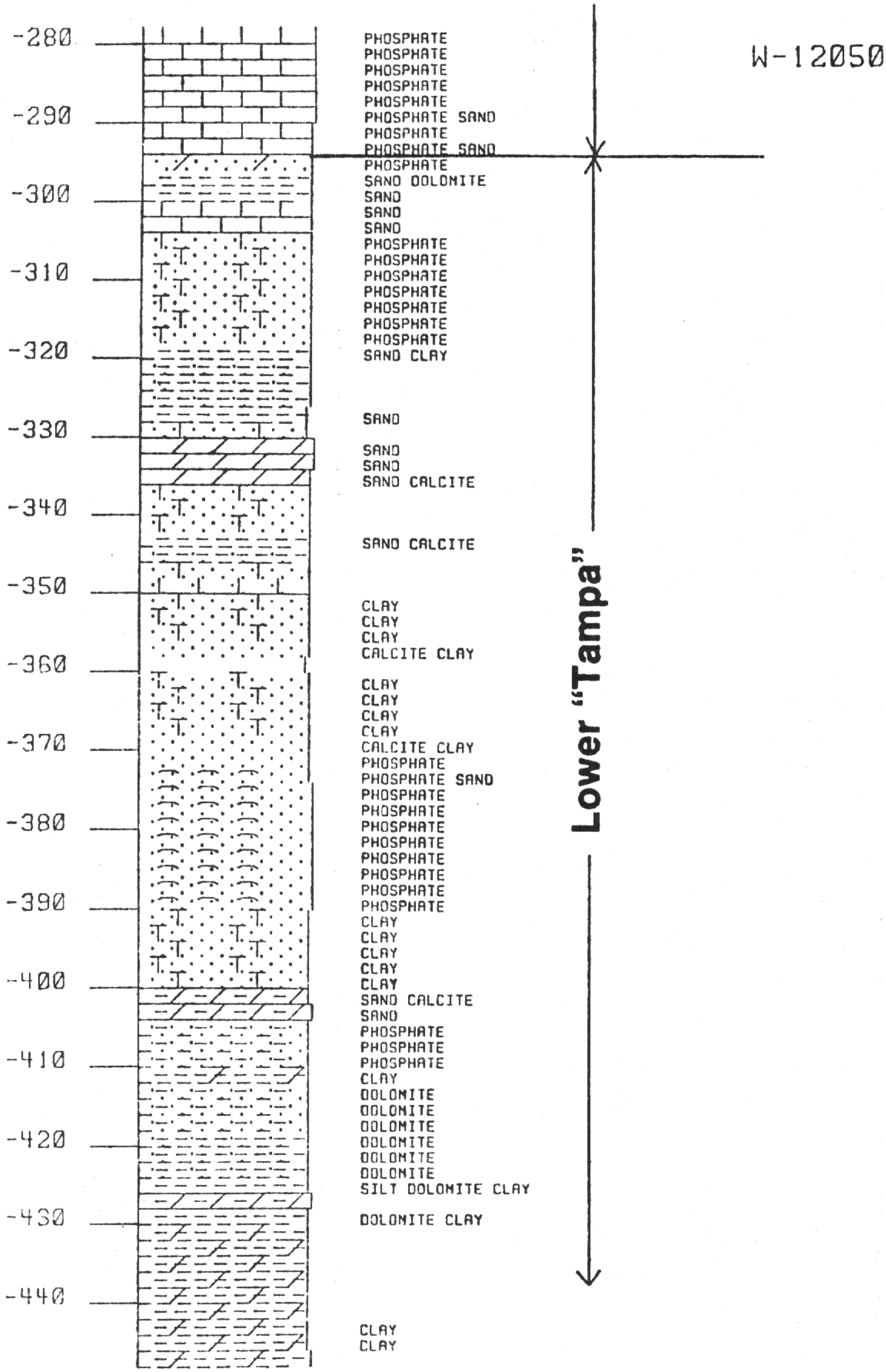


Figure No. 12 (Continued)

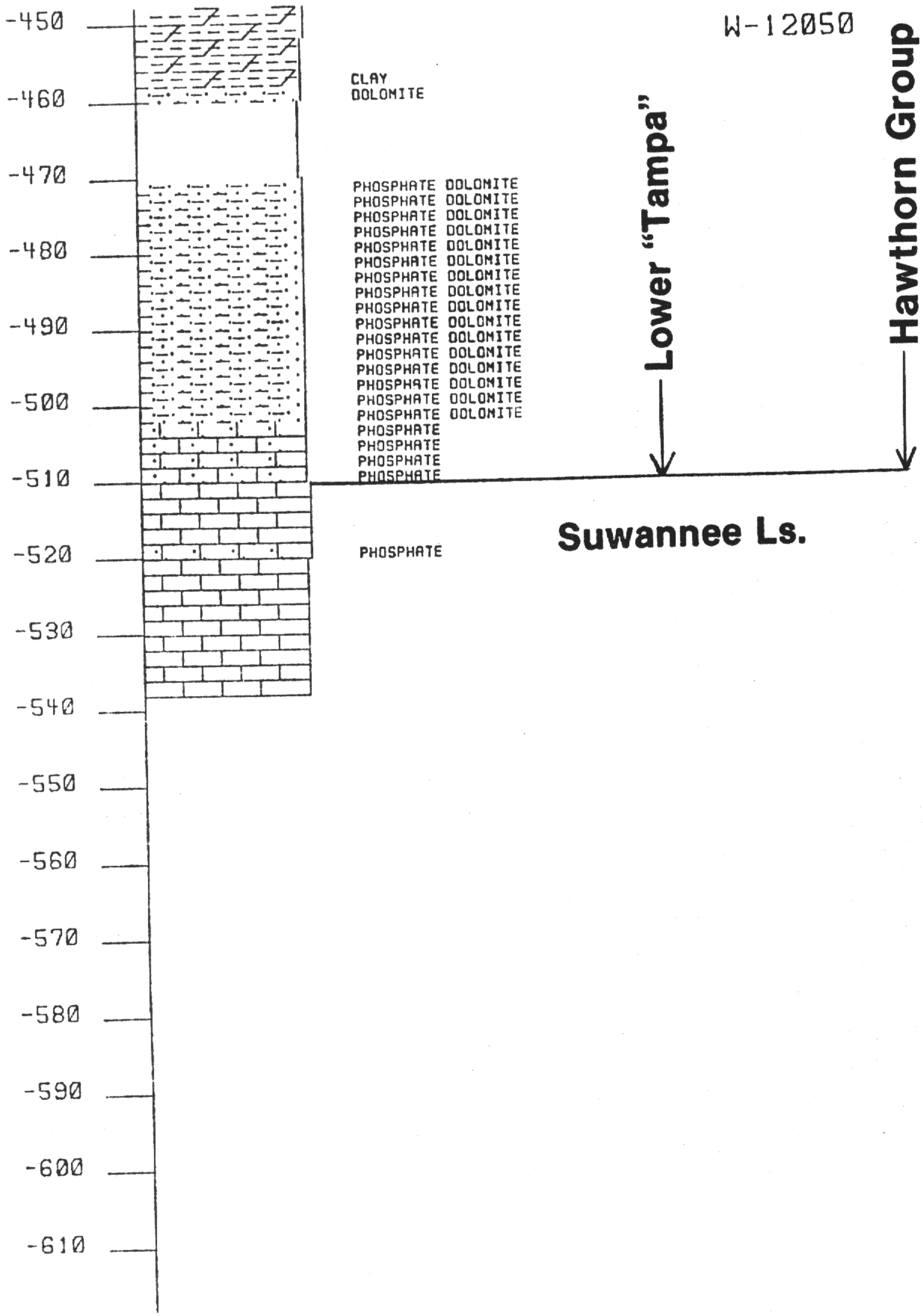


Figure 12 (Continued)

The thickness of the upper "Tampa" and the "Tampa" is variable. Where the upper "Tampa" is distinct from the lower part it reaches a maximum thickness of more than 200 feet, whereas when it is not differentiated the "Tampa" may reach thicknesses up to 300 feet.

Like the lower "Tampa" discussed earlier, the age and correlations of the upper "Tampa" are very speculative due to the paucity of data and paleontologic studies.

The type Tampa Formation as defined by King and Wright (1979) differs from the "Tampa" and the upper "Tampa" only in the percentage of phosphate present. The definition of the Tampa Formation by King and Wright allows for "essentially no phosphate in the unit." The thickness of the Tampa also ranges from 0 to 120 feet.

Overlying the various Tampa units everywhere, except in the extreme updip area, is what is here referred to as the lower "Hawthorn." The lower "Hawthorn" is equivalent to the carbonate portion of the Hawthorn Formation of former usage and has been called the Hawthorn carbonate unit. In the most updip occurrences of the Tampa units the overlying unit varies from the upper "Hawthorn" or Hawthorn clastic unit to the post-Hawthorn undifferentiated sediments as at the Tampa Formation type section (figure 12). The contact with the overlying units varies from sharp, where the undifferentiated sediments or the upper Hawthorn overlie the Tampa, to gradational, downdip where the lower Hawthorn overlies these units.

The lower "Hawthorn," or the Hawthorn carbonate unit, is a sequence of quartz sandy, phosphatic, sometimes clayey, dolomites and limestones with occasional beds of carbonate-rich quartz sand and thin clays. The sediments of this unit range from white (N9) to yellowish gray (5Y8/1) in color. Phosphate content of this unit varies widely from a trace (uncommon) to as much as 30 percent. The average phosphate percentage, however, is 7 to 8 percent.

The thickness of the lower "Hawthorn" ranges from 0 at its updip limits to greater than 300 feet downdip (figures 10,11). Near the center of the peninsula, along the line of cross section B-B', it appears that the upper "Tampa" grades laterally and vertically into the carbonates of the lower Hawthorn while to the west, along the present coast, the upper "Tampa" grades vertically into it.

The lower "Hawthorn" grades into the upper "Hawthorn" through an increase in clastic material, which becomes more accentuated upward. Thus the upper "Hawthorn" is a sequence of interbedded quartz sands, clays, and dolomites. The sands are calcareous to dolomitic, clayey, phosphatic, and vary in color from yellowish gray (5Y8/1) to olive gray (5Y4/1). The phosphate within these sands ranges to 40 percent and is of economic value in the southern extension of the Central Florida Phosphate District. The sand is generally fine to medium grained, poorly sorted, and slightly indurated.

The clay beds of the upper "Hawthorn" are generally thin and discontinuous. They contain quartz sand, silt, dolomite, and varying amounts of phosphate. The clays range in color from yellowish gray (5Y8/1) to olive gray (5Y4/1) and are predominantly palygorskite and montmorillonite. (Hall, 1983).

The carbonate beds of the upper "Hawthorn" are generally dolomite and dolosilts. They also contain dispersive quartz sand, phosphate, and clay and are variably indurated. The color of these sediments ranges from white (N9) to yellowish gray (5Y8/1). Carbonate beds are less common in the southern extension of the Central Florida Phosphate District in Hardee, Manatee, Sarasota and Desoto counties (see Hall, 1983) and become more common west and south of the district.

The Bone Valley Formation, the main phosphate bearing unit mined in Central Florida, is included in the upper "Hawthorn" of this paper. The Bone Valley is composed of a series of clay and sand layers commonly containing abundant phosphorite sand and gravel. These deposits are generally thin except where they fill paleokarst features.

The thickness of the upper "Hawthorn" ranges from 0 at its updip limit, and in general thickens downdip where it may reach thicknesses of 175 feet.

The entire Hawthorn Group dips gently in a general south and southeasterly direction (figure 4). It thickens from its updip limits to more than 700 feet in south Florida (figure 5).

The Hawthorn Group (in a restricted sense; applying only to what was the Hawthorn Formation) has long been considered Middle Miocene based on limited molluscan fauna (Cooke, 1945). However, as was previously discussed for the Hawthorn Group of north Florida, there is good correlation between Hawthorn sediments in north Florida with datable sediments in the Georgia Coastal Plain. The correlations thus suggests an Early Miocene age for the Hawthorn Group and Middle Miocene for others. As previously discussed also, the Hawthorn clastic sediments in the F.P.L. # 1 core in Martin County further suggest a possibility of Late Miocene age for some of the upper Hawthorn Group. This is particularly true of the sediments currently recognized as part of the Tamiami Formation. It has been suggested by Hunter and Wise (1980) that these sediments be placed back into the Hawthorn from which they were removed by Parker, et al (1955). Because there is documented evidence of sediments other than Middle Miocene age occurring in the surrounding areas, and which are correlative with Hawthorn sediments, it is suggested here that portions of the former Hawthorn Formation (upper and lower Hawthorn of this paper) incorporate sediments perhaps as old as Early Miocene and as young as Late Miocene in the western central peninsular area.

SOUTH FLORIDA

The Hawthorn Group in southern Florida has long been a poorly understood unit. Major inferences on the stratigraphic placement of this unit in this region were made by Mansfield (1939), Parker and Cooke (1944), Parker, et al. (1955) and Bishop (1956). Although these authors did not always agree on the placement of the boundaries of this sequence, they did all recognize it as being composed of very phosphatic and sandy clays, and limestones. The major difficulties that arise concern the delineation of the formations above and below the Hawthorn, which often tend to be sandy and phosphatic as well. Generally their delineation relies on characteristic fauna or age.

In the recent past there have been several attempts to alleviate the boundary problems associated with the Hawthorn Group in this area. Hunter and Wise (1980), for instance, suggested that the overlying Tamiami should be redefined to include only the original limestone described by Mansfield in 1939, namely the Ochoppee Limestone member and its lateral equivalents. They also indicated that the Tamiami Formation as established by Parker, et al. (1955), is actually a chronostratigraphic unit that lacks formal lithologic description and boundaries, thus does not conform to the American Code of Stratigraphic Nomenclature. This concept is followed in this paper. The lower stratigraphic contact of the Hawthorn Group is also very difficult to define in some areas because of the gradational nature of the basal Hawthorn beds (Tampa Formation) with the Suwannee Limestone.

The occurrence of phosphate and appreciable quantities of quartz sand within the Tampa Formation and Suwannee Limestone in Southwest Florida has created many problems for geologists recently trying to correlate these beds in this area (see, Missimer and Banks (1982), Wedderburn, et al. (1982), and Peacock (1983)). Similar difficulties exist on the East Coast as shown by Mooney (1980), Armstron (1981), and Wedderburn and Knapp (1983).

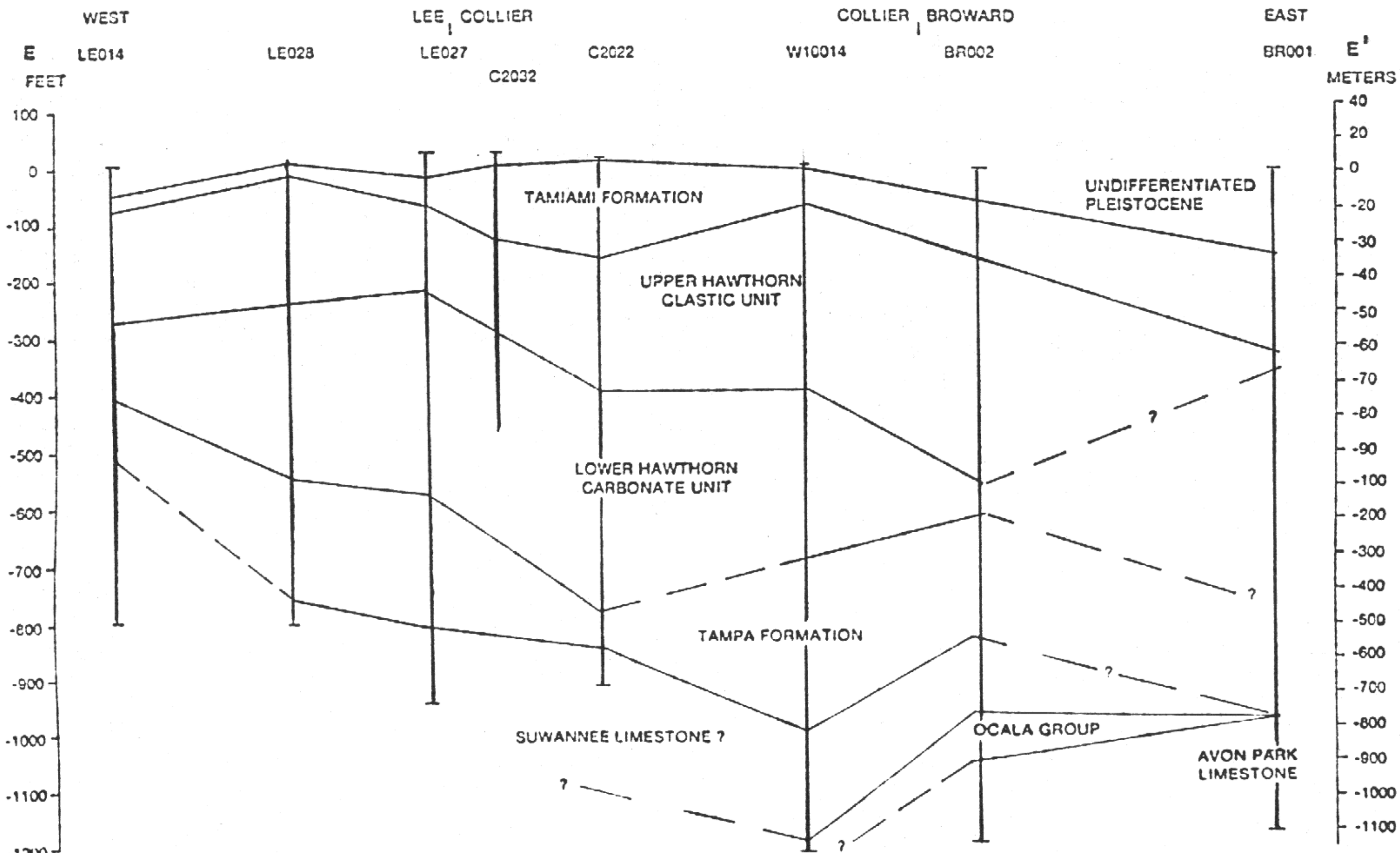

WEST
LEE | COLLIER
COLLIER | BROWARD
EAST
E
LE014
LE028
LE027
C2032
C2022
W10014
BR002
BR001
E'
FEET
METERS
100
0
-100
-200
-300
-400
-500
-600
-700
-800
-900
-1000
-1100
-1200
40
20
0
-20
-30
-40
-50
-60
-70
-80
-90
-100
-200
-300
-400
-500
-600
-700
-800
-900
-1000
-1100
TAMIAMI FORMATION
UNDIFFERENTIATED
PLEISTOCENE
UPPER HAWTHORN
CLASTIC UNIT
LOWER HAWTHORN
CARBONATE UNIT
TAMPA FORMATION
SUWANNEE LIMESTONE ?
OCALA GROUP
AVON PARK
LIMESTONE
?

Figure 13

The Hawthorn Group is present throughout south Florida and ranges in thickness from 200 to more than 800 feet (figure 5) and dips to the southeast (figure 4). Its lithologic sequence is very diverse, and only general trends can be described regionally. This is due in large part to the lack of quality core data in this area.

The Hawthorn Group is immediately underlain by three formations in different areas of south Florida (table 1). In southwest, south central and southernmost Florida the group is underlain by the Suwannee Limestone. The Suwannee contains considerable percentages of quartz sands (up to 15 percent in some intervals) and its contact with the Hawthorn Group is gradational. The Suwannee thins from near the Collier County border into Broward County and pinches out somewhere near the southeastern Florida coast (figure 13). The Hawthorn Group is then underlain by the Avon Park Limestone and the break between the two is an abrupt disconformity. Rubble beds frequently occur at this break and the Eocene carbonate beds are easily identified. In Palm Beach, Martin and St. Lucie counties the base of the Hawthorn is underlain by the Ocala Group. As in other parts of south Florida where Eocene Age limestones underlie the Hawthorn, the contact is an easily discernible unconformity. The base of the Hawthorn dips to the south and southeast in south Florida being relatively high in parts of Lee (-500 ft. NGVD) and St. Lucie Counties (-650 ft. NGVD) and much deeper in Broward and Dade counties. (-900 ft. NGVD).

The Hawthorn Group in south Florida can be divided into at least two, or possibly three units. Lithologically the group is composed of a heterogeneous sequence of phosphatic, sandy, clayey, calcareous and dolomitic sediments. The uppermost bed is frequently an olive (10Y5/4) phosphatic, sandy, slightly clayey dolosilt. The uppermost unit also has a much higher percentage of clastic sediments than the lower two units, and in southwestern Florida is separated from them by a major disconformity (Missimer, 1978). Although reworked intervals are common in the Hawthorn in other parts of south Florida, they cannot be mapped consistently enough to be identified as regional disconformities.

For the purpose of discussion, the unit within the Hawthorn Group will be referred to in ascending order as the "Tampa Formation," the lower Hawthorn Carbonate Unit, and the upper Hawthorn Clastic Unit. As stated previously, the raising of the Hawthorn to group status is informal at this time, but will be proposed by Scott (manuscript in preparation) in the near future.

The Tampa Formation in southwestern Florida occurs as a white (N9) to very pale orange (10YR 8/2) biogenic, micritic, very fine grained limestone that contains up to 10 percent quartz sand and has a phosphate content that varies from a trace to 2 percent, but in some intervals may be as high as 15 percent. Dolomite beds also occur infrequently throughout the unit. They are normally light gray (N7) in color, very fine grained to microcrystalline, with a phosphate content up to 10 percent and quartz sand content up to 15 percent.

Figure 14 is a lithologic and stratigraphic column from a deep core near Buckingham in Lee County. It shows that down to a depth of 756 feet the lithology was still equivalent to the Tampa. However, the gamma log has shown that a dramatic decrease in radioactivity occurs at about 740 feet, thus the beds below this decrease could be placed in the Suwannee Limestone by many geologists not having core control. The Suwannee Limestone in southwestern Florida is in some areas up to 500 feet thick. The significant percentages of quartz sand (up to 15 percent) and the presence of sandstones in some intervals suggest that at least the upper portion of this unit should be placed in the Tampa Formation.

The Tampa Formation in southeastern Florida differs slightly from that of southwestern Florida. It generally occurs as a yellowish gray (5Y7/2) sandy and phosphatic limestone. The gradational nature of the Tampa Formation into the lower Hawthorn carbonates in this area, however, makes it very difficult to separate from superjacent unit. In the St. Lucie County well

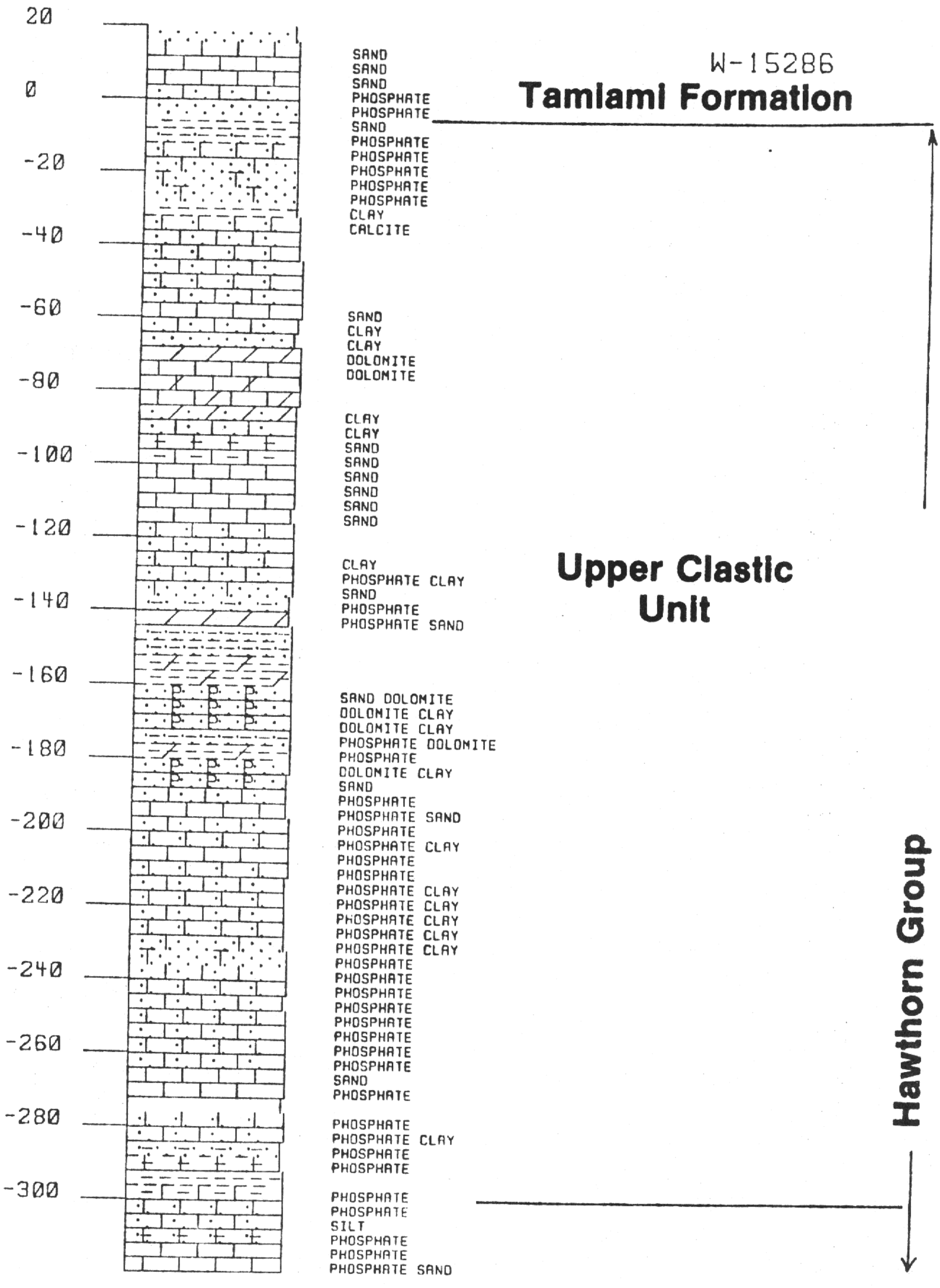
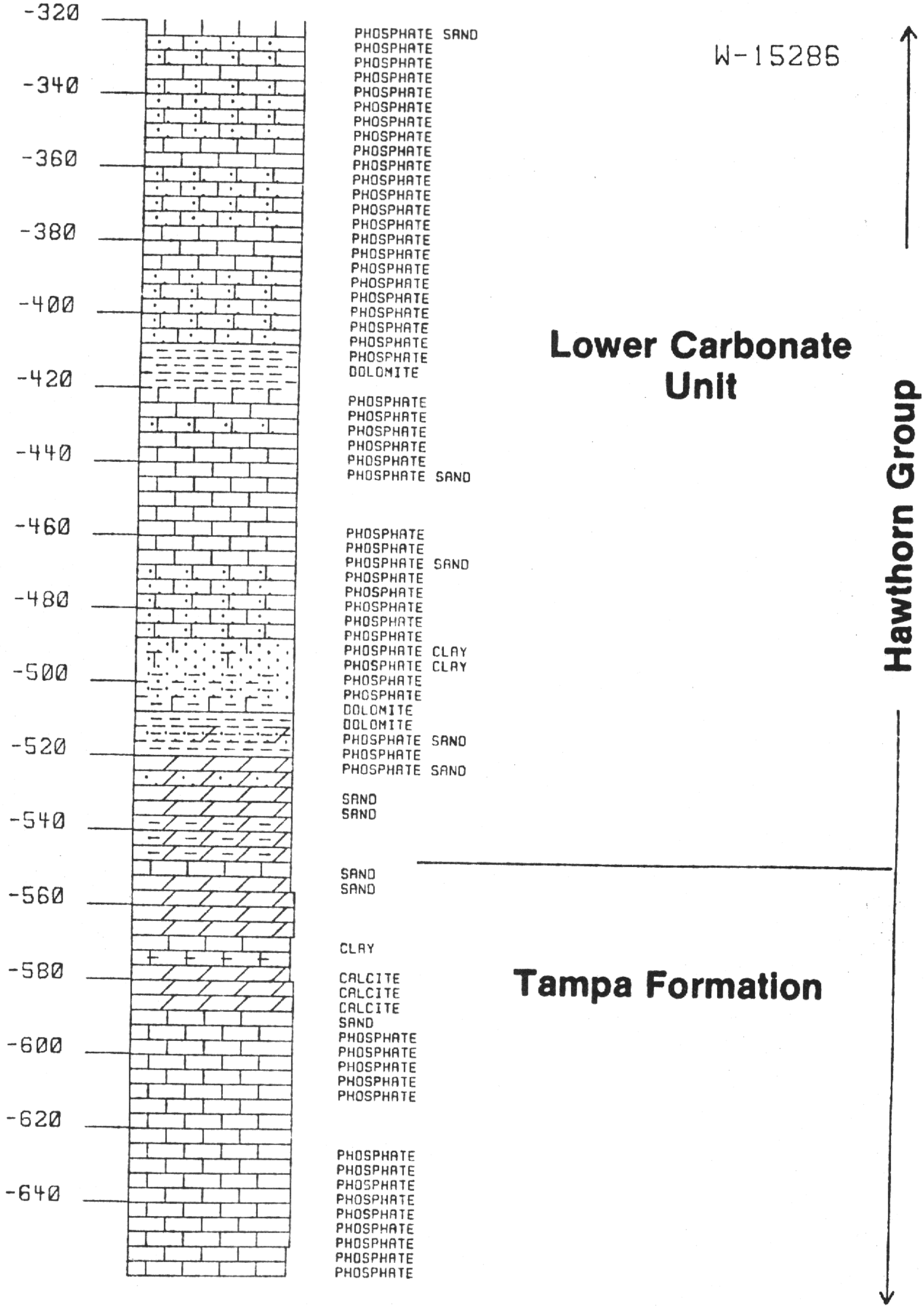


Figure No. 14 Figure



No. 14 (Continued)

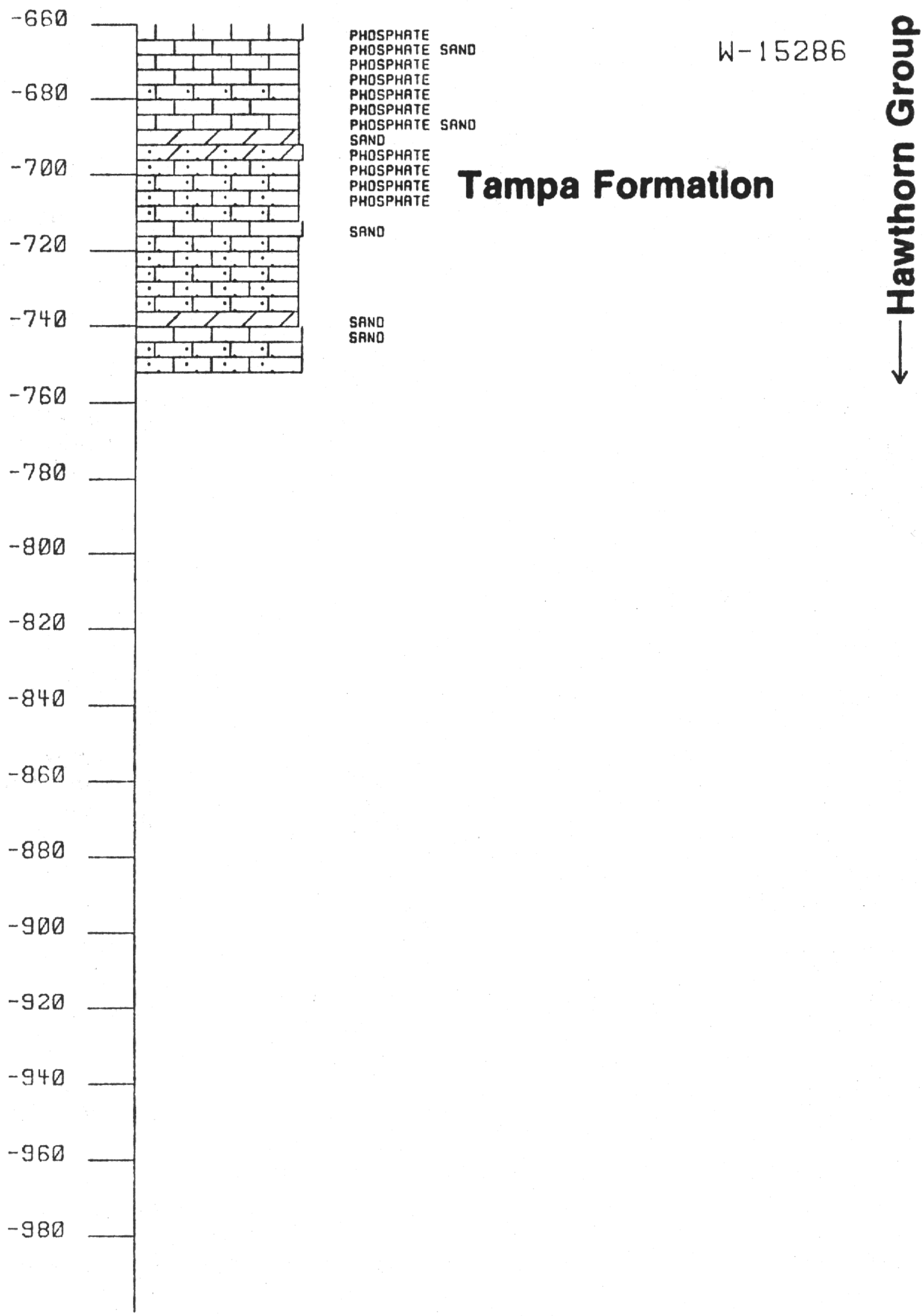


Figure No. 14 (Continued)

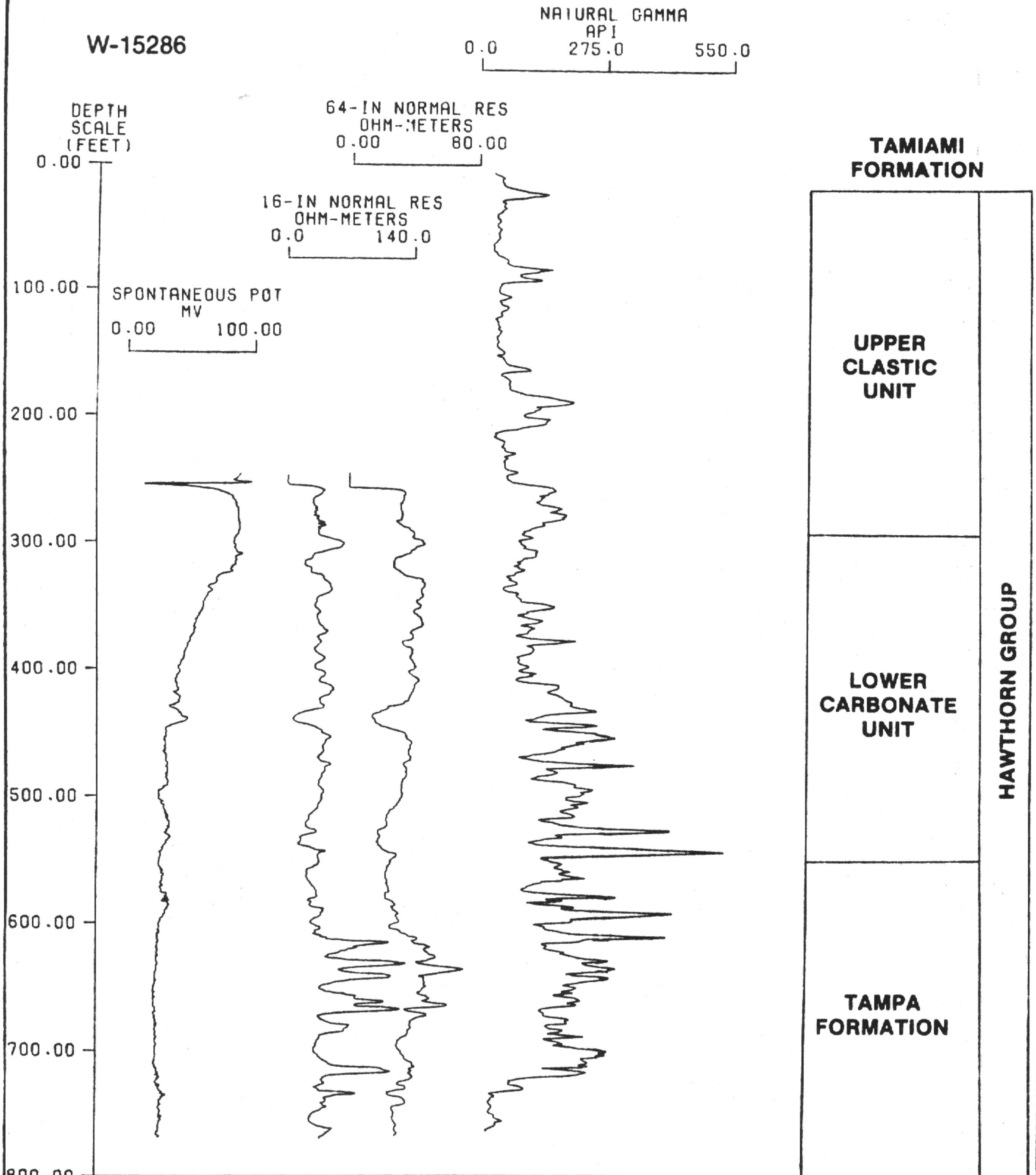

W-15286
NATURAL GAMMA
API
0.0
275.0
550.0
DEPTH
SCALE
(FEET)
0.00
100.00
200.00
300.00
400.00
500.00
600.00
700.00
800.00
64-IN NORMAL RES
OHM-METERS
0.00
80.00
16-IN NORMAL RES
OHM-METERS
0.0
140.0
SPONTANEOUS POT
MV
0.00
100.00
TAMIAMI
FORMATION
UPPER
CLASTIC
UNIT
LOWER
CARBONATE
UNIT
TAMPA
FORMATION
HAWTHORN GROUP

Figure No. 15

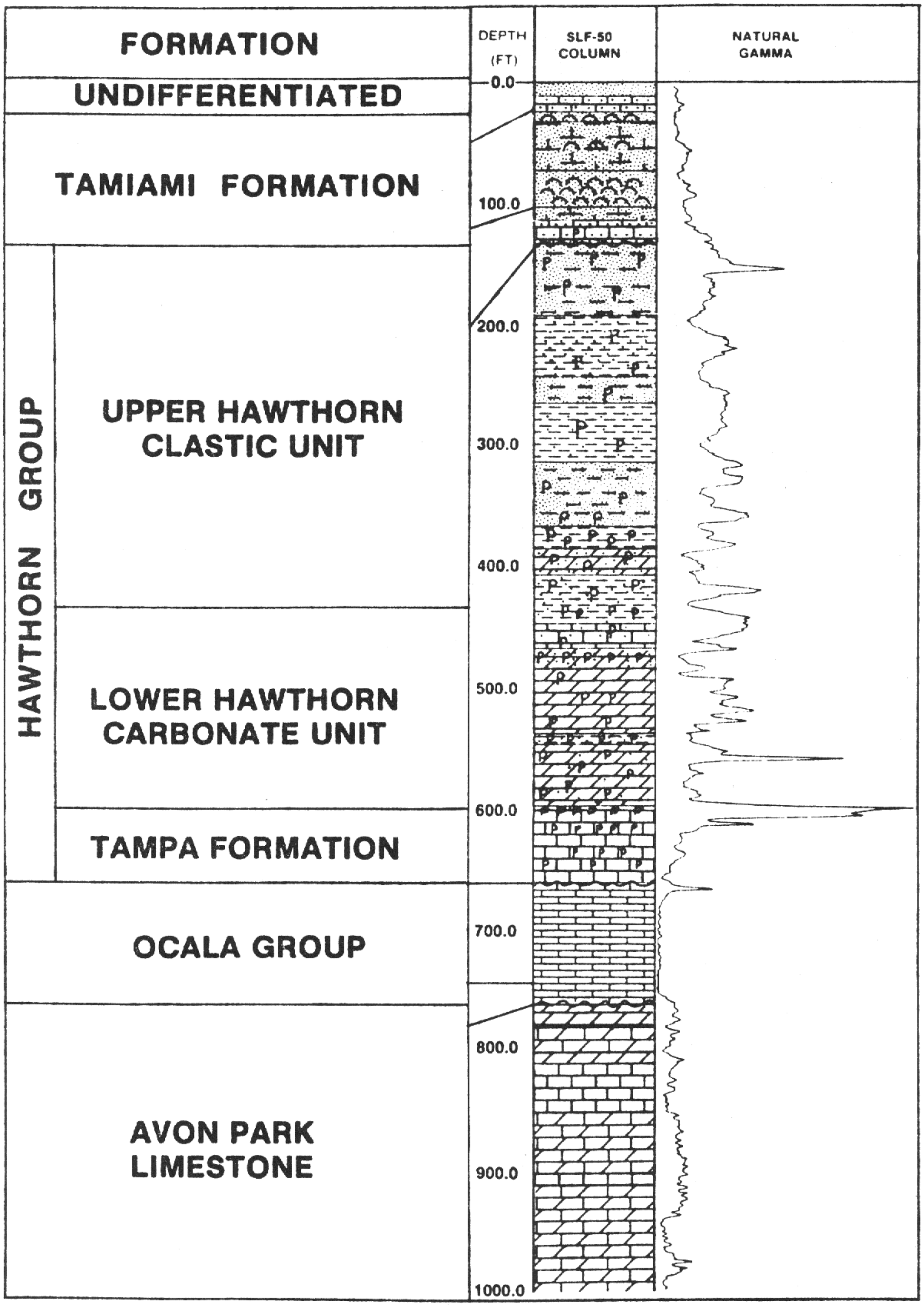


Figure No. 16 GEOLOGIC COLUMN ST. LUCIE COUNTY, FLORIDA

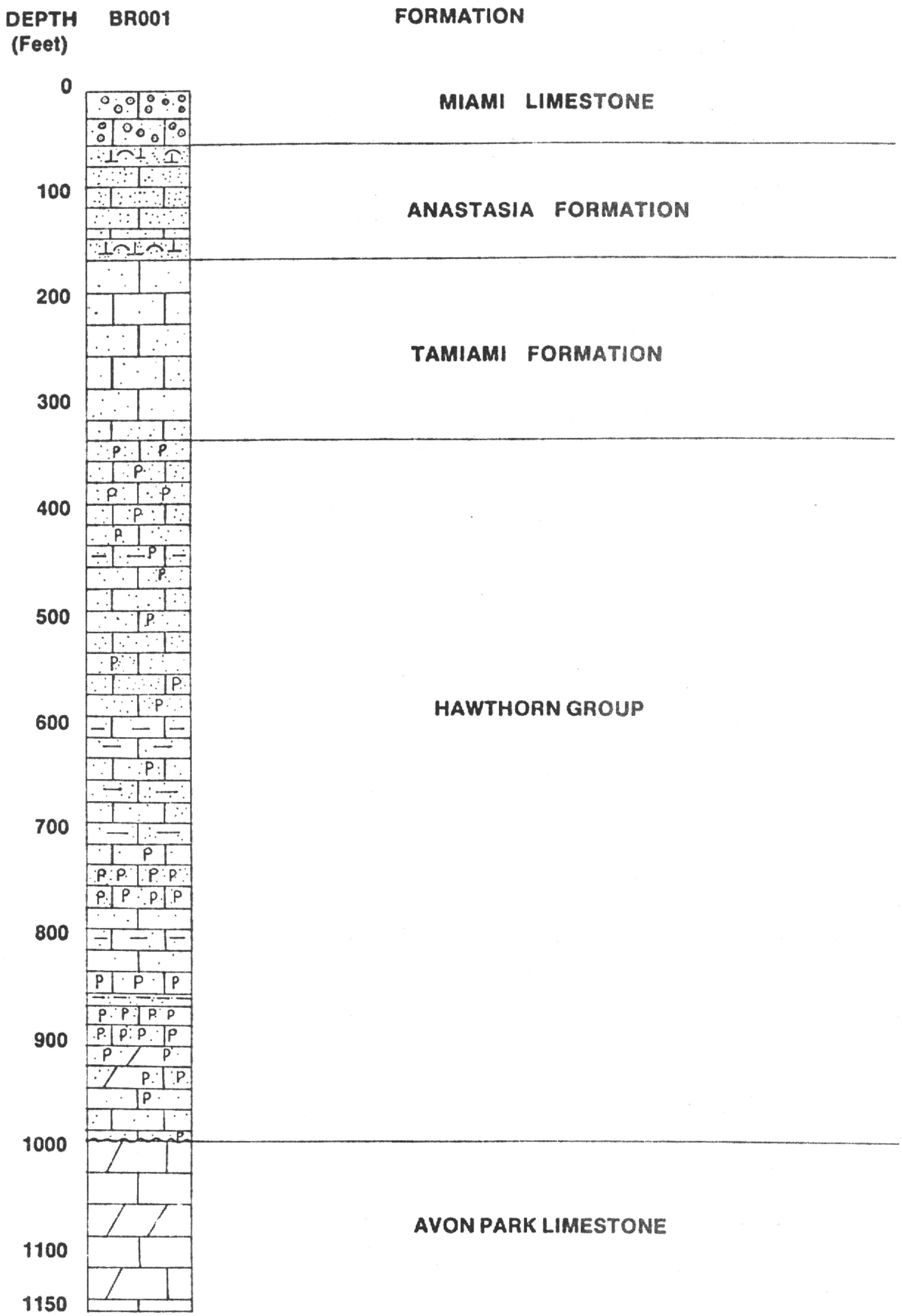


Figure No. 17
Lithologic column in Broward County,Florida

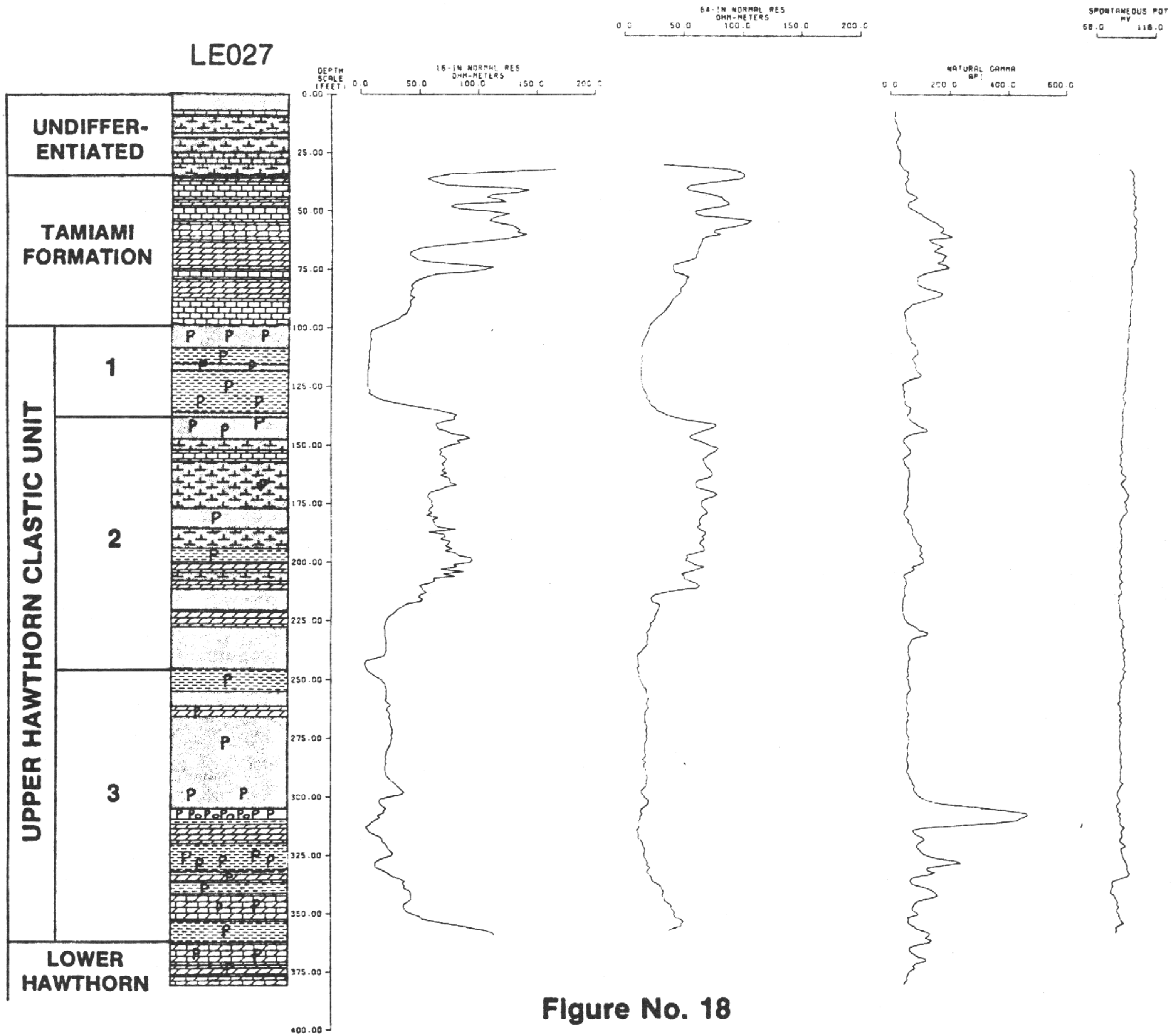

LE027
UNDIFFER-ENTIATED
TAMIAMI FORMATION
UPPER HAWTHORN CLASTIC UNIT
1
2
3
LOWER HAWTHORN
DEPTH SCALE (FEET)
0.00
25.00
50.00
75.00
100.00
125.00
150.00
175.00
200.00
225.00
250.00
275.00
300.00
325.00
350.00
375.00
400.00
16-IN NORMAL RES OHM-METERS
0.0 50.0 100.0 150.0 200.0
64-IN NORMAL RES OHM-METERS
0.0 50.0 100.0 150.0 200.0
NATURAL GAMMA API
0.0 200.0 400.0 600.0
SPONTANEOUS POT MV
68.0 118.0

Figure No. 18

(figure 15) the Tampa was inferred based upon the smaller quantities of phosphate and more micritic nature of the beds, whereas in the Broward County well (figure 16) the Tampa could not be differentiated from the Lower Hawthorn carbonates.

Although the "Tampa" in central Florida area can be divided into two units, it is very difficult to recognize these two units in south Florida. Figure 13 shows the configuration of the Tampa Formation from Lee to Broward counties. the unit dips gently to the east and its thickness varies dramatically between Lee and Dade counties.

The fauna contained within the Tampa Formation is principally marine, but most shells are highly recrystallized causing difficulties in determining taxa. Foraminifera, mollusks, bryozoans and corals are the most abundant fossils present. Typical benthonic foraminifera which have been used by previous workers (see Cole 1941) to delineate the Tampa in this area are *Sorites* and *Archias floridanus*. These species are present throughout the unit in south and southwestern Florida, but are absent in southeastern Florida north of Broward County. In the St. Lucie County area beds equivalent to the Tampa Formation were found to be of possible Oligocene Age (Armstrong, 1982).

The lower Hawthorn Carbonate Unit in south Florida consists of a sequence of sandy and phosphatic dolosilts, dolomites, and limestones. The lowermost bed is frequently a yellowish gray (5Y7/2) to greenish gray (5GY6/1) phosphatic dolosilt. This unit commonly contains phosphatized shark teeth and molluk fossils. It exhibits very high radioactivity as evidenced by the Gamma Ray logs (figure 15 and 16). The dolomite beds vary from a very pale orange (10YR8/2) to a moderate yellowish brownn (10YR5/4) and contain between 1 and 15 percent phosphatic sand. The dolomites are highly recrystallized and individual crystals are normally very fine grained and euhedral. The limestones within the lower Hawthorn vary from a white (N9) to a yellowish gray (5Y8/1) and contain up to 15 percent phosphatic sand and 12 percent quartz sand. Texturally, these limestones are microcrystalline to coarse grained and are commonly very micritic with intraclasts and other skeletal material being the larger grains. In many intervals the limestones are poorly indurated and are sometimes referred to as marls. Shell beds, oyster bioherms and quartz sand beds occur infrequently in the lower Hawthorn, usually near the dolosilt beds.

The limestone beds predominate in the lower Hawthorn and vary from 1 to 40 feet in thickness, whereas the dolosilts interbed vary from 6 inches to 20 feet in thickness. Dolosits beds are commonly bioturbated and in general sandier in their upper portions. Dolomite beds occur frequently near the base of the lower carbonate unit.

The thickness of the lower Hawthorn carbonate unit in southwestern Florida varies from a minimum of 125 feet in western Lee County to more than 375 feet in central Collier County. The top of the unit lies within a hundred feet of the surface in the Cape Coral area in Lee County and dips gently to the east and south into Collier County where it occurs at depths greater than 300 feet.

In southeastern Florida the thickness of the Lower Hawthorn Carbonate Unit varies from about 150 feet in St. Lucie County (figure 16) to more than 500 feet in Broward County (figure 17). The abrupt thickening of the unit to the south is due in large part to the change in the elevation of the Avon Park Limestone and absence of the Ocala Group in southernmost Florida. Additionally, the upper Hawthorn Clastic Unit takes on a more carbonate nature and is not discernible over much of this area.

The upper Hawthorn Clastic unit can be divided into at least three lithic zones (Figure 18) in Lee County and parts of Hendry and Collier counties. All of these zones contain varying percentages of phosphate, quartz sand, and clayey dolosilts. In other parts of south Florida these zones are not distinct.

In southwestern Florida the lowermost zone (3) consists of yellowish gray (5Y7/2) to grayish olive (10Y5/2) sandy and phosphatic dolosilt with thin interbeds of sandy phosphatic limestones and dolomite. Olive gray (5Y3/2) clay beds sometimes occur near the top of this zone. X-ray diffractogram analysis shows the dominant clay mineral present in these beds to be montmorillonite with minor percentages of kaolinite and illite. This zone characteristically contains a rubble bed or reworked interval of very coarse rounded and sometimes abraded phosphatic limestone and dolomite pebbles. In addition, there may be up to 20 percent coarse phosphate and quartz sand present in this interval. This particular interval was regarded as evidence for a major regional disconformity by Missimer (1978), although at that time the upper Hawthorn Clastic unit was believed to be a part of the Tamiami Formation. The middle zone (2) normally contains very light gray (N8) phosphatic and sandy limestone and yellowish gray (5Y7/2) phosphatic dolomites. Some intervals within zone contain well rounded quartz sands as well as fragments of well indurated sandstones (10YR8/2), both in a carbonate matrix. This zone in southern Lee County has been formally named the Lehigh Acres Member of the Tamiami Formation by Peck, et. al. (1979). However, since that time most geologists who worked on this zone in this area have included it within the Hawthorn (see Missimer and Banks, 1981; Wedderburn, et al. 1982; and Peacock, 1983. The upper zone of the Hawthorn clastic unit is composed predominantly of phosphatic dolosilts interbedded with poorly indurated limestones, shell beds, and green clays, with the most phosphatic sediments occurring in the lower part of the zone. The dolosilts are commonly light olive gray (5Y5/2) to yellowish gray (5Y7/2) with up to 20% quartz sand and silt, and up to 10% phosphatic sand.

The upper Hawthorn Clastic Unit in southeastern Florida is predominantly composed of phosphatic and sandy dolosilts occasionally interbedded with thin limestone beds. The three zones that comprise this unit in southwestern Florida are not as distinct in southestern Florida. The rubble beds that mark the base in southwestern Florida are not present in southeastern Florida, but do occur erratically near the base of the clastic unit the St. Lucie County (figure 16).

The fossil assemblages within the Upper Hawthorn Clastic Unit contain diverse groups of mollusks, bryozoans, corals, benthonic and planktonic foraminifera, and diatoms. The diatoms and planktonic foraminifera occur within the upper most dolosilt beds. According to Peck, et al. (1979) the assemblages of planktonic foraminifera range in age from late Miocene to mid-Pliocene (Zones N17 to N20 of Blow, 1969).

The upper part of the Hawthorn Clastic Unit in parts of Glades, Collier, Hendry and Highlands County contains well rounded quartz and phosphate pebbles. These sediments were referred to by Bishop (1956) as being of deltaic or fluviatil origin. These coarse phosphatic pebbles occur erratically and are here included within the upper Hawthorn. It is suggested that these sediments are of a fluviatil origin, hence their concentration in certain areas only, as are the characteristic of deposits due to stream transport.

GEOPHYSICAL INTERPRETATION

Throughout much of the state, the Hawthorn Group has a very distinct gamma-ray signature, which is consistently much higher than the underlying sediments of the Suwannee Limestone and the Ocala Group, and usually higher than the overlying sediments.

The intensity of the Hawthorn's characteristic gamma ray signature is ascribed to the uranium contained in the phosphate and clays. Many of the lithologic units within the Hawthorn Group equate with distinctive gamma ray patterns. Typical gamma ray pattterns and the lithologic units of the Hawthorn Group are shown in figures 19, 20,21, and 22.

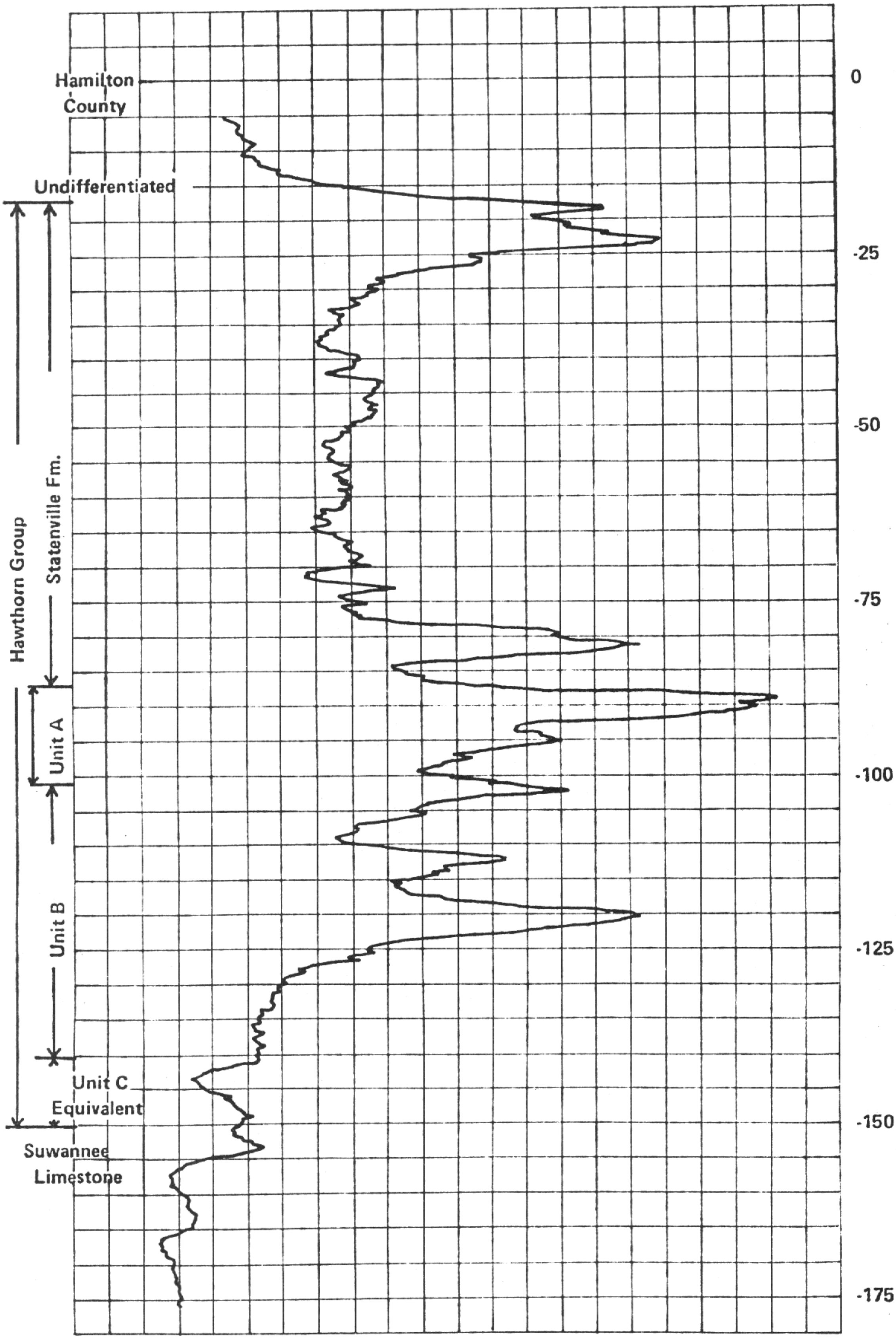

Hamilton County
Undifferentiated
Hawthorn Group
Statenville Fm.
Unit A
Unit B
Unit C Equivalent
Suwannee Limestone
0
-25
-50
-75
-100
-125
-150
-175

Figure No. 19

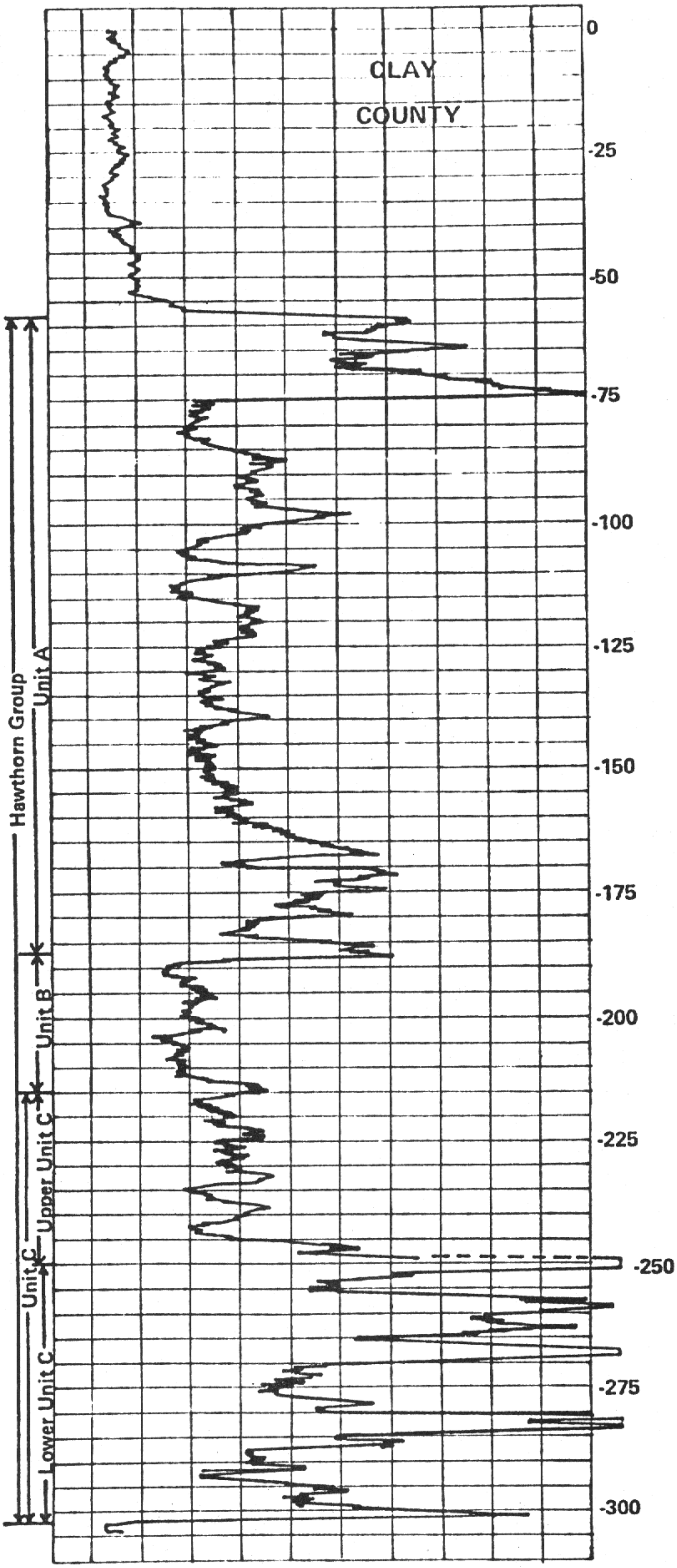

CLAY
COUNTY
0
-25
-50
-75
-100
-125
-150
-175
-200
-225
-250
-275
-300
Hawthorn Group
Unit A
Unit B
Upper Unit C
Unit C
Lower Unit C

Figure No. 20

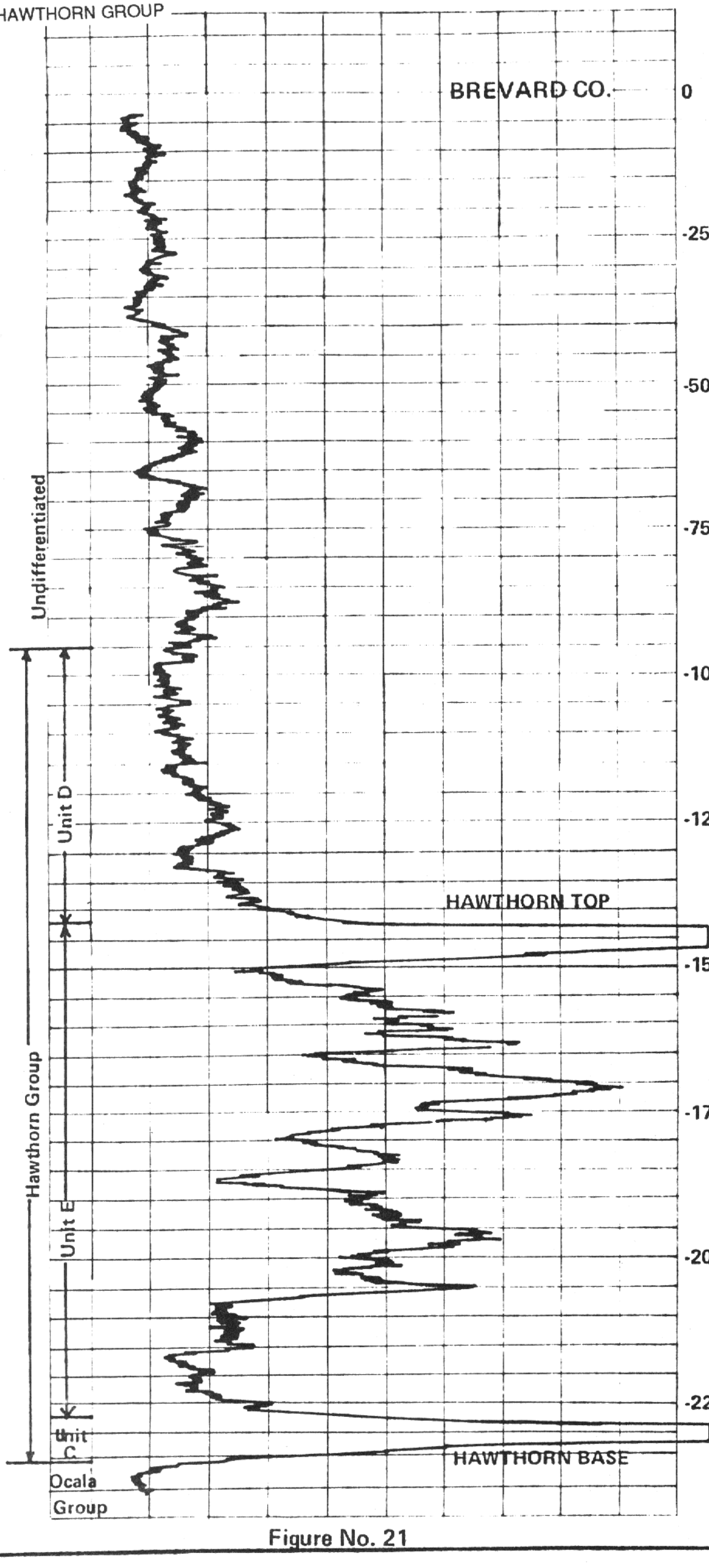

BREVARD CO.
0
-25
-50
-75
-100
-125
-150
-175
-200
-225
Undifferentiated
Unit D
Unit E
Unit C
Hawthorn Group
HAWTHORN TOP
HAWTHORN BASE
Ocala Group

Figure No. 21

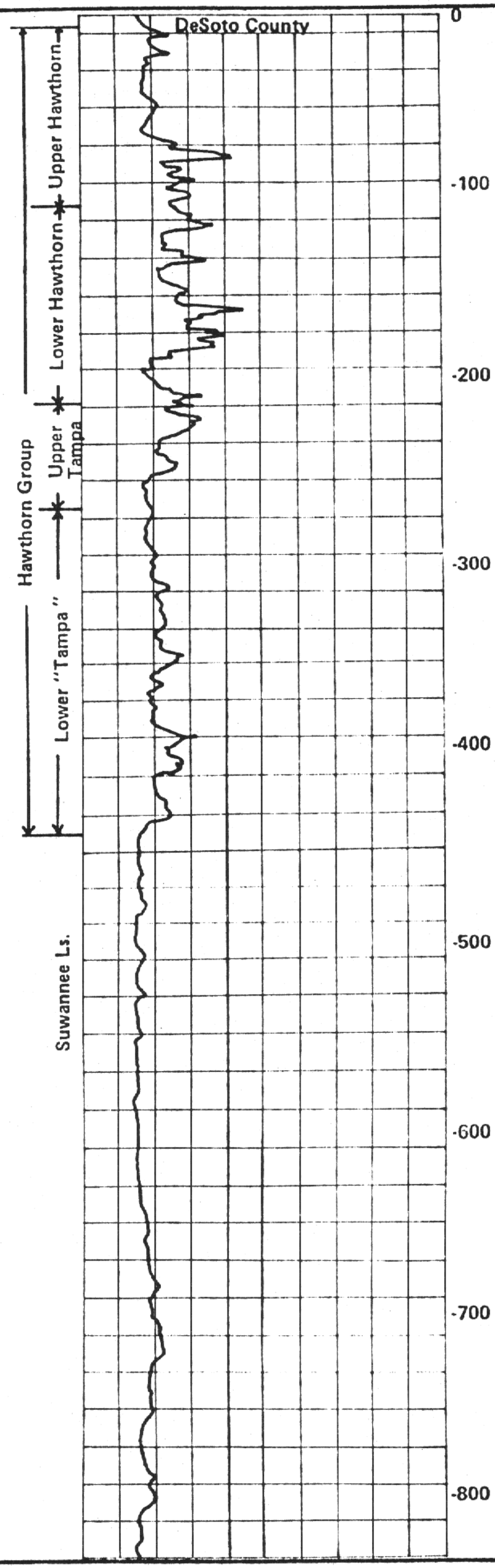

DeSoto County
0
-100
-200
-300
-400
-500
-600
-700
-800
Upper Hawthorn
Lower Hawthorn
Upper Tampa
Hawthorn Group
Lower "Tampa"
Suwannee Ls.

Figure No. 22

It is important to note that as the Hawthorn Group thickens to the south from central Florida the characteristic patterns on the gamma ray logs begin to diminish in intensity. This attenuation is caused by general decrease in phosphate with distance from the suggested source areas in central Florida (Riggs, 1979).

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